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# NATURAL HISTORY

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# NATURAL HISTORY

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*January 1980*

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*Robert G. Goelet, President*
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# Authors

While a graduate student at the University of Arizona, **Stan L. Lindstedt** became intrigued with desert shrews because they "seem so unfit for desert survival." "Unfortunately," he recounts, "these tiny insectivores are difficult to observe. After a year and a half I had not captured *any*. Finally, with a little luck, and a good deal of persistence, I found a method for capturing them—overturning dead agave plants." Lindstedt's work on the survival of desert shrews took place in the Sonoran Desert of Arizona between 1974 and 1977. Currently an International Fellow of the Swiss National Science Foundation, stationed at the Anatomy Institute of the University of Berne, Lindstedt is again studying shrews, this time the Etruskian shrew, the world's smallest mammal. Its weight, two grams, is less than that of a dime.

Coauthor **James H. Jones** is a first-year veterinary student at Colorado State University, where he is studying aerodynamic valving of air flow in avian lungs. He has done fieldwork on bobcat density and prey selection in the central Arizona desert. On tap is research on the respiratory responses to heat stress in ostriches, which he plans to do this summer at the University of Cape Town. His involvement with desert shrews began in a graduate school course in environmental physiology at the University of Arizona in which Lindstedt was the teaching assistant. "My interest in the shrews stemmed from the subject and from Bud Lindstedt's research," Jones recalls. As a footnote, he adds, "My Ph.D. work at Duke was under the professor who had been the major professor to Lindstedt's major professor. I stayed 'in the family,' so to speak."

The web forms of spiders have a special fascination for **William G. Eberhard**. An arachnologist with a research background in behavioral biology, he has spent considerable time in the tropics studying spiders and their webs, and the insects that make adaptive use of the webs. Eberhard, who received his Ph.D. from Harvard, was once an associate professor of biology at the Universidad del Valle, Colombia. He is now on the staff of the Smithsonian Tropical Research Institute in Panama and the Escuela de Biología of the Universidad de Costa Rica.

"We were haunted by Darwin; his ghost was always around," says **John K. Stevens** about his six-week stay in the Galápagos Islands with his wife and coauthor, **Katharine E. Parsons**. They first learned of the fish they studied there while honeymooning in Maine six years ago. Born and educated in the United States, Stevens is a neurobiologist who has recently taken up a new post as associate professor of physiology at the Playfair Neuroscience Laboratory, a neurological "think tank" at the University of Toronto in Canada. His current specialty is the study of microcircuits in cats' eyes.

Parsons was a student of her husband-to-be in a college biology course. She works as a free-lance writer of health and science articles and has spent about ten years doing nature photography.

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"The strikingly different uses of the swastika in the Third Reich and in India lead inevitably to speculation about its original meaning," says **Stanley A. Freed**, who with coauthor **Ruth S. Freed** has studied urban influences and modernization in a village in northern India. The Freeds first did fieldwork in the village from 1957 to 1959 and recently returned from a follow-up trip on which they noted the changes that have occurred during the last twenty years. Both authors are Ph.D.s in anthropology from the University of California at Berkeley and have done research among several North American Indian groups. Stanley A. Freed is curator of anthropology at the American Museum of Natural History. Ruth S. Freed, professor of anthropology at Seton Hall University, New Jersey, is a research associate in the Museum's Department of Anthropology.

As a college student, California-born **Henry T. Lewis** began spending the first of eleven summers fighting forest fires as a park ranger with the National Park Service. In an attempt to understand why California Indians had traditionally set fires in grasslands, brush, and forests, he learned that their strategy was similar to what fire ecologists currently advocate for the management of wildland areas. This discovery led to his monograph on *Patterns of Indian Burning in California* and to his more recent research and a film on the Indian uses of fire in northern Alberta. Now a Canadian citizen and chairman of the Department of Anthropology at the University of Alberta in Edmonton, Lewis is making a comparative study of aboriginal uses of fire in the tropical savanna region of northern Australia.

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# Postscripts

## Tahoe's Decline

Last fall, Charles Goldman climbed into a seventeen-foot submarine and dove 1,000 feet beneath the surface of Lake Tahoe. It was his first chance to see the depths of a lake he has studied for twenty years. And what he saw in the course of several dives confirmed the assessment that he and the Tahoe Research Group made in "Tahoe's Troubled Waters" (*Natural History*, January 1975)—"Tahoe is changing for the worse each year."

One of the things Goldman saw was attached algae growing as far down as 600 feet. Tahoe is naturally nutrient poor and would not be expected to have much algal growth. Nonetheless, it has been increasing in fertility over the years because of construction and development around the lake. These disturbances add to the burden of sediment (and nutrients) that streams and spring runoff carry into the lake. Goldman also saw vast areas of lake bottom covered with fine sediment that looked "like a blanket of ooze."

Most important, according to Goldman, was his discovery of large numbers of pregnant mysis shrimp near the bottom of the lake. After their introduction as fish food about six years ago, mysis devastated two native forms of zooplankton, *Daphnia* and *Bosmina*. Recent surface counts have shown the shrimp population to be leveling off, but since pregnant mysis are staying near bottom and not migrating to the surface at night as they generally do, those counts are probably low.

Goldman's underwater exploration, which was financed by a California newspaper, the *San Jose Mercury News*, was not without its pleasures. He got a "completely new perspective on the lake" and was particularly surprised by the "incredible diversity of the underwater habitat," which ranged

*Experimental submarine begins descent into Lake Tahoe*

UPI

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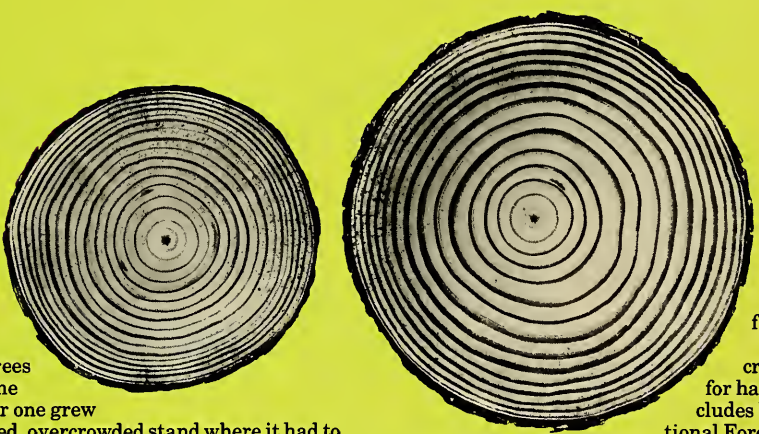

These log slices dramatically show the value of modern, scientific forest management. Both (shown 36% of actual size) are from trees of about the same age. The smaller one grew in an unmanaged, overcrowded stand where it had to compete for sunlight and moisture. The other is from a grove that was thinned to give the best trees room to thrive.

This is just one of many ways forest management can help meet a predicted doubling of domestic demand for wood and paper products in the next 50 years.

The forest industry has learned how to help Mother Nature grow more trees, faster, by applying scientific forest management techniques: encouraging natural regrowth, planting superior seeds and seedlings, fertilizing, protecting against disease and insects, thinning, watching carefully until time to harvest — then starting the cycle again.

## Demand keeps rising.

Forest management like this is vital because every year Americans need more homes, more paper products, more packaging and containers, more fuelwood, more of the thousands of other essential products that only the forest can provide.

So far, the country's commercial forest has been able to keep up with demand. (*Commercial forest,* as defined by the U.S. Forest Service, is *all* forestland—whether owned by individuals, government or the industry—that is capable of, and potentially available for, growing repeated crops of trees for harvest. It includes land in National Forests but not in National Parks or Wilderness areas.)

But trees aren't grown equally fast by all commercial forest owners. Though industry has made striking advances on its lands, productivity is lower on privately owned lands and seriously lagging in National Forests.

## Productivity not up to potential.

Overall, the U.S. Forest Service estimates average productivity of all commercial forestland is only 61 percent of potential. And at the same time, actual acreage in commercial forests keeps shrinking, as land is withdrawn for homes, highways and other needs of an expanding population.

So we as a nation still have a long way to go if our wood and paper products are not to become scarce and expensive.

If you'd like to be better informed on how important it is to keep America's forests productive, write American Forest Institute, P.O. Box 873, Springfield, VA 22150 for a free booklet, "The Great American Forest."

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from ooze-covered bottom to grassy hills to the sheer cliffs of underwater canyons.

## Good News, Bad News

Mark Newton and Russell Smith saw a bleak future ahead for the California mountain king snake when they wrote "The Snake That Lost Its Habitat" (*Natural History*, June/July 1975). An "ice age relict" that has little appropriate habitat left in the state, the snake occupies a particularly precarious niche in the Santa Monica Mountains near Los Angeles. There, it lives only in the canyons, a habitat that is also popular with developers.

The good news is that in 1978 Congress passed the National Parks and Recreation Act, creating, among other things, the Santa Monica Mountains National Recreation Area, a 150,000-acre chunk of the mountain range within which the National Park Service is to buy undeveloped land. A land acquisition plan was due to Congress at the beginning of 1980, and in fiscal 1980 the Park Service is getting its first acquisition funds.

The problem is in turning the legislative mandate into an actual park. The Park Service has been authorized to spend $155 million over five years to buy land; of that, $35 million is for 1980. The White House tried to trim this year's funds to $13 million, but Congress restored the balance. Even so, land in the Santa Monicas goes for astronomical prices, with some of the more luxurious homes costing $1 million or more. And as might be expected, the Park Service will not always be dealing with willing sellers. Developers are opposed to the park and have threatened to force the Park Service into lengthy law suits.

Finally, the Park Service is not the only government body concerned with the Santa Monicas. The city of Los Angeles and several smaller communities, each with their attendant agencies, the state Coastal Commission, and Los Angeles and Ventura counties all have some stake in the mountain range.

Even with the money and the law behind it, the Park Service's work has just begun.

## The War on Evolution

In the 1970s, wrote Norman Newell in "Evolution Under Attack" (*Natural History*, April 1974), believers in the biblical account of creation renewed their crusade against the teaching of evolutionary theory in the public schools. Now they have carried the fray from classroom to museum, challenging an exhibit on evolution in the Smithsonian Institution's new National Museum of Natural History.

Modern creationists are biblical fundamentalists, but frequently go forth into the courts under the banner of science, not religion. They claim that the notion that God created the world and all basic kinds of living things in the biblical six days is supported by the scientific evidence. On the other hand, creationists also claim that the theory of evolution is not science at all, but disguised theology.

In the court challenge to the federally financed Smithsonian exhibition—"Dynamics of Evolution"—Dale Crowley, director of the National Foundation for Fairness in Education in Washington, D.C., said the Congress was, in effect, financing religion. He charged that by presenting only the theory of evolution without information on other theories of creation, the Smithsonian was using public money to establish a "religion of secular humanism" and therefore violating First Amendment provisions for separation of church and state.

In the suit filed in federal district court in Washington, Crowley said that he and his coreligionists were forced either to violate their beliefs by visiting the evolution exhibit or to give up their right of access to public property. In addition, he said, the Smithsonian was out of bounds in giving any interpretation to the animals and other items in the exhibit, since its congressional mandate was only to display objects, not to interpret them.

Judge Barrington D. Parker was not impressed with Crowley's arguments and dismissed his suit, saying that the Smithsonian had not only the right but the mandate to diffuse scientific knowledge and that the theory of evolution, as presented by the museum, was indeed science and not religion. As to whether the offensiveness of the exhibit infringed on Crowley's rights, the judge quoted the Supreme Court decision in a similar case: "The state has no legitimate interest in protecting any or all religions from views distasteful to them."

The exhibit opened last spring but the decision was appealed, and until the legal struggles are over, no one at the Smithsonian cares to comment on them.

*James Gorman*

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# Deadly Botulism

*Lethal and incurable, this centuries-old disease is now thought to be the cause of some cases of infant crib death*

### by Lance L. Simpson

Botulism is to modern medicine what Billy the Kid was to the Old West. It is an ornery and untamed disease known widely for its killing ways. Botulism has earned this notorious distinction for two reasons. First, it is caused by botulinum toxin, a substance that is nature's most deadly poison. Second, it is not curable. Patients struck by the disease can survive only if their bodies can withstand the toxin's assault upon their nervous systems.

Botulism is most commonly encountered as a form of food poisoning. Both history and legend suggest that this type of food poisoning has been known for centuries. During the past few years, however, medical investigators have discovered a new and unsettling aspect of botulism that, sadly enough, can only increase our fear of this disease. To understand why, we must first understand something about the toxin and about food poisoning.

Botulinum toxin is produced by the bacterium *Clostridium botulinum*, an organism closely related to *C. tetani*, the bacterium that produces tetanus toxin. Were it not for the existence of botulinum toxin, tetanus toxin would be regarded as the most deadly poison.

Botulinum toxin is synthesized in at least eight immunologically distinct types. Generally speaking, individual strains of *C. botulinum* synthesize only one type of toxin. Although they differ in their immunogenicity, the various toxins all have a similar mechanism of action in poisoning the nervous system. Epidemiological studies have shown that human outbreaks of botulism are associated with four types of toxins. Of these, the type known as A toxin is the most lethal and the one that has been most carefully studied.

For type A toxin to cause an outbreak of food poisoning, an unbroken chain of events must occur. First, and most obvious, a potential food must be contaminated with *C. botulinum*. Next, the food must be packaged in a way that will permit the bacteria to grow and multiply, and in so doing produce the deadly toxin. Clostridia are anaerobic organisms; that is, they can live in the absence of oxygen and can grow inside most containers used by commercial food processors. To prevent the growth of clostridia and the production of toxin, food processors use various techniques: the most common is heating foods to high temperatures. This retards bacterial growth and completely destroys any toxin that may have formed. In addition, most processed foods are cooked before they are eaten, and this step inactivates the toxin molecule, which is unstable at high temperatures.

An outbreak of botulism is possible only if a food is contaminated with

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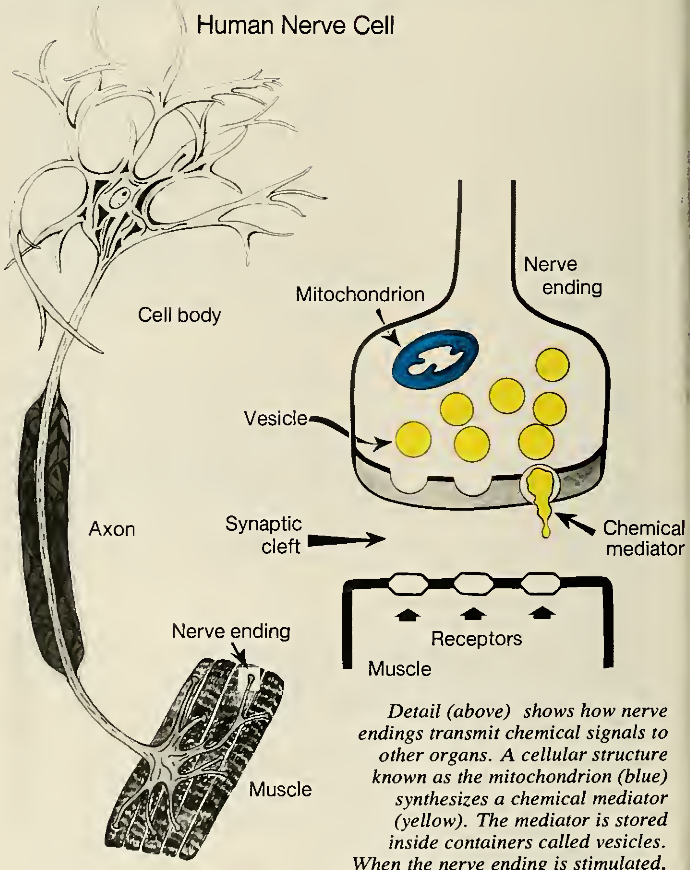

*Detail (above) shows how nerve endings transmit chemical signals to other organs. A cellular structure known as the mitochondrion (blue) synthesizes a chemical mediator (yellow). The mediator is stored inside containers called vesicles. When the nerve ending is stimulated, the vesicles release the mediator, which diffuses across the synaptic cleft and triggers an impulse in the muscle.*

Zena Lupjan

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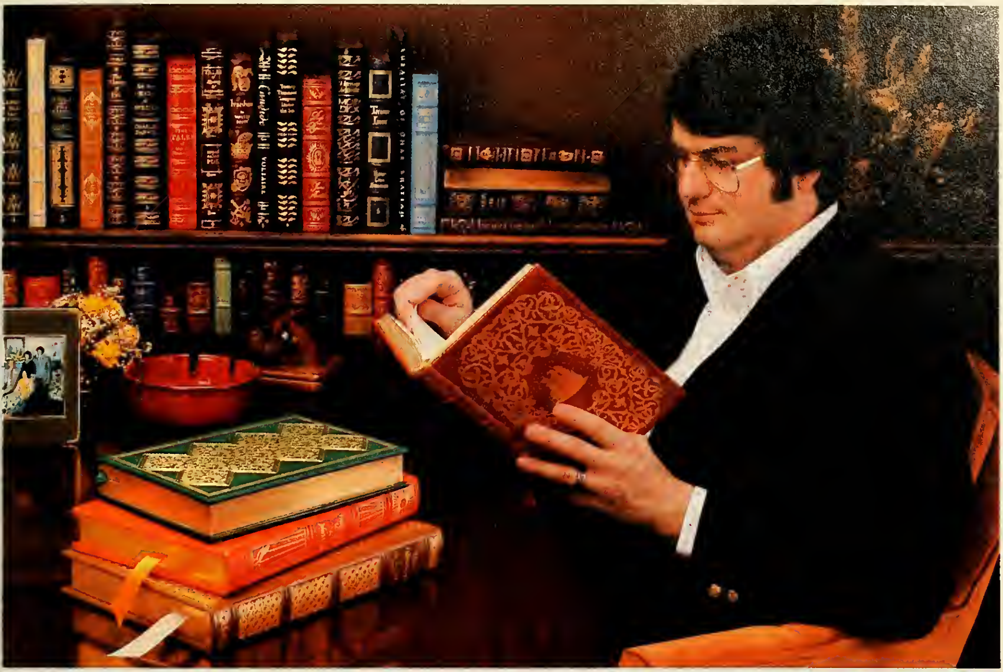

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Nevertheless, accidents do happen. Each year there are several outbreaks of botulism. Sometimes the outbreak is confined to one family, as is usually the case when a home-canned food is implicated. More tragically, the outbreak may involve dozens of people, all of whom have consumed a commercially prepared and distributed food. In either case, the clinical outcome is the same.

To understand how botulinum toxin exerts its poisonous effects, we must take a close look at the human nervous system and its fundamental component, the individual nerve cell. Each nerve cell has three main parts—a cell body, an axon, and a nerve ending. A nerve impulse normally arises in or near the cell body and is conducted outward by the axon. The nerve ending, or terminal, is a specialized structure that transmits impulses from itself to the structure that it innervates, or is connected to, for example, another nerve, a muscle, or a gland.

Nerve endings are not electrically coupled to the organs they innervate. Therefore, a nerve action potential that is propagated down the axon into the terminal cannot electrically excite the organ to which it is connected. There are several reasons for this; the most important is that a small anatomical cleft, the synapse, separates nerve endings from the structures they innervate. The gap created by the synapse prevents nerve endings (presynaptic structures) from being electrically coupled to innervated organs (postsynaptic structures).

In humans, synaptic transmission is a chemical process. Chemical mediators, known as synaptic transmitters, are stored inside microscopic containers, or vesicles. When an action potential invades the nerve terminal, it causes these vesicles to migrate toward the nerve membrane and dump their transmitter substance into the synaptic cleft. The transmitter diffuses across the synapse and collides with receptors on the postsynaptic cell. The result of this drug–receptor collision is the initiation of a new action potential.

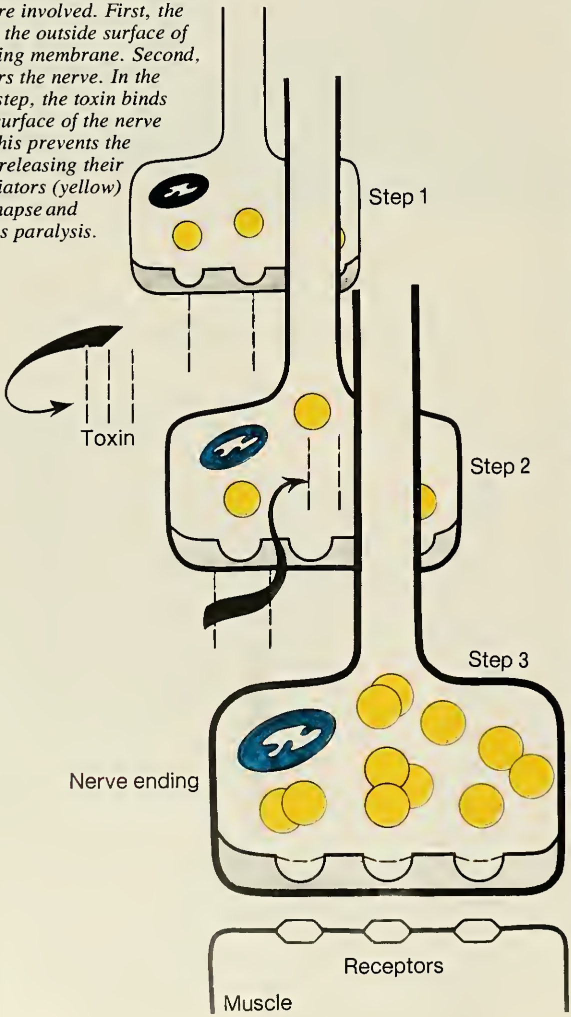
There are many different synaptic transmitters in the human body. Interestingly enough, botulinum toxin paralyzes only those synapses at which the transmitter substance is acetylcholine, a compound that has numerous effects on the human body. This specificity of toxin effect is advantageous to scientists because much is known about acetylcholine-mediated transmission.

Acetylcholine is synthesized inside the nerve ending. Two small molecules, acetate and choline, are enzymatically linked to form the transmitter. Once synthesized, acetylcholine is stored inside vesicles. When a nerve impulse flows into the nerve ending, the vesicles migrate toward the presynaptic nerve membrane, then jettison their stores of acetylcholine into the synapse. The transmitter substance diffuses across the synapse, where it promptly bumps into cell receptors. As already explained, the acetylcholine–receptor collision triggers a new impulse.

Scientists have known for many years that botulinum toxin poisons cholinergic transmission, but research is still being done to determine pre-

## Interaction between Botulism Toxin and Nerve Ending

*Three steps are involved. First, the toxin binds to the outside surface of the nerve ending membrane. Second, the toxin enters the nerve. In the crucial third step, the toxin binds to the inside surface of the nerve membrane. This prevents the vesicles from releasing their chemical mediators (yellow) across the synapse and thereby causes paralysis.*



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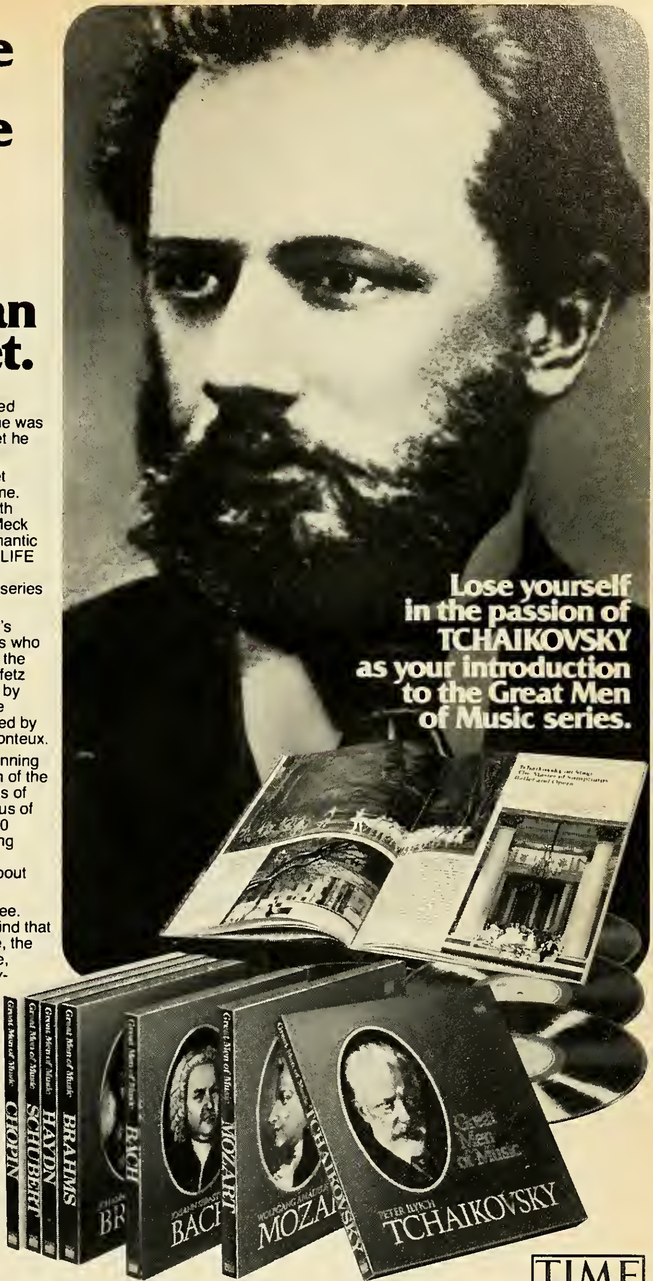
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cisely what happens. Investigators believe that the interaction between the toxin molecule and the nerve ending is complex. More precisely, they believe that at least three sequential steps are involved and that when all three have been completed, the cholinergic synapse becomes helpless and paralyzed.

In the first step, the toxin binds to the outside surface of the nerve membrane, but this binding does not alter the function of the nerve cell. In the second step—referred to as a translocation step—the toxin molecule, or some portion of it, enters the nerve. There is uncertainty about how the toxin molecule gets from the outside to the inside of the nerve, but according to one intriguing hypothesis, empty vesicles that have released their acetylcholine into the synapse may capture the toxin molecule and transport it back into the nerve cell. There are, of course, other possibilities.

The third and crucial step in the sequence is the one that produces paralysis of transmission. Most investigators believe that once inside the nerve, the toxin molecule binds to the internal surface of the nerve membrane. In so doing, it causes a change in the structure or function of the nerve membrane. As a result, vesicles can no longer meld with the nerve membrane to release their stores of acetylcholine. In effect, the toxin produces a "logjam." Although nerve impulses can still be propagated into the nerve endings, they do not cause the vesicles to discharge their acetylcholine. Instead, as time passes and the number of nerve impulses increases, the vesicles become backed up, in logjam fashion, inside the nerve terminal.

This sequence of events seems very intricate, an impression that might be true if attention were limited to botulinum toxin. But if we examine the actions of other bacterial toxins that can cause poisoning, a fascinating trend begins to emerge. Most of the truly poisonous toxins, such as cholera, diphtheria, and tetanus toxin, possess similarities to botulinum toxin. Most notably, all of these toxins bind to the outside of their target cells without producing any ill effects. Only when the various toxins move inside their target cells do they begin to cause damage.

The target cells upon which botulinum toxin acts are cholinergic nerves. Cells of this type are found in both the central nervous system (the brain, for example) and the peripheral nervous system. Patients who suffer from botulism, however, experience poisoning only of their peripheral nerves. The brain is protected by a functional and morphological shield called the blood-brain barrier. Botulinum toxin cannot penetrate this barrier, so central cholinergic nerves are spared.

The peripheral nervous system has two major divisions, the motor system and the autonomic system. The motor system governs all types of voluntary movement, such as walking, talking, and breathing. Virtually all motor nerves are cholinergic and as such are vulnerable to botulinum toxin. The victims of severe botulism will experience complete paralysis of all voluntary nerves.

The autonomic nervous system governs the function of many body organs not under voluntary control, such as the heart, the vasculature, the bowel, and the bladder. Many, but not all, autonomic nerves are cholinergic. Those that are can be poisoned by botulinum toxin. The effect of the toxin manifests itself in many ways, including erratic blood pressure and heart rate, constipation, and urinary retention.

Some organs, like the eye, have both voluntary and autonomic innervation. As a result, the function of the eye is especially impaired by botulinum toxin; symptoms include dilated pupils and blurred and double vision.

For the patient stricken with botulism, the experience can be devastating, if not fatal. The patient with severe botulism cannot move, cannot even breathe. All voluntary muscles are paralyzed. In addition, there is widespread disruption of autonomic function. Unfortunately, there is no cure for botulism. There is no form of drug treatment, and certainly no surgical procedure, that abolishes the symptoms of the disease. Instead, physicians must rely on two poor substitutes for a cure, these being supportive therapy and time.

Supportive therapy is an integral part of the practice of medicine. Loosely speaking, supportive therapy means the use of artificial methods to sustain a bodily function. For example, a botulism patient who cannot breathe or who has difficulty breathing can be maintained on artificial respiration. Likewise, the patient who cannot eat or swallow food will be fed intravenously. If the bowel or bladder is not working properly, artificial techniques can be used to void the body of its excreta. In short, every effort is made to

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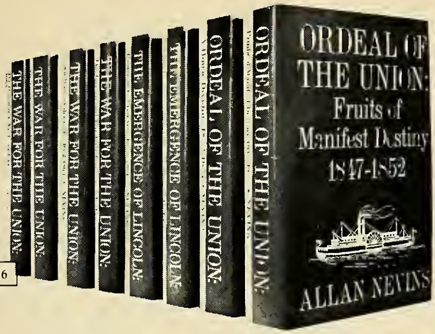
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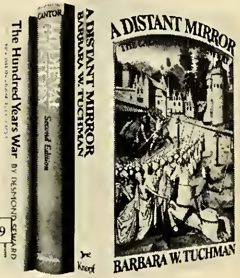
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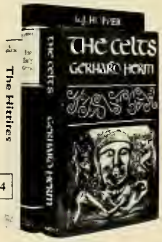
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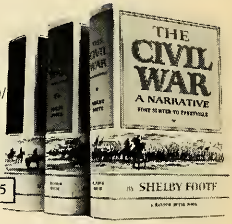
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sustain those bodily functions that have fallen prey to botulinum toxin.

The second factor is time. If there is any ray of hope for the botulism victim, it is that the effects of the toxin are reversible. After many days or, in severe cases, many months, toxin-induced paralysis diminishes and then disappears.There is as yet no clear explanation for why the paralytic symptoms disappear, but there is a widely held assumption. As time passes, the nervous system may synthesize replacement parts for those that were attacked by the toxin. Therefore, the goal of the physician is to provide whatever supportive therapy may be needed so that the nervous system will have time to mend itself.

In its best-known guise—as a form of food poisoning—botulism is a disease worthy of dread. It is hard to imagine learning anything that could make the disease appear even worse than it already is. But something new and unpleasant has been learned.

Strictly speaking, foodborne botulism is not an infection; it is a form of intoxication. Ingestion of the bacteria does not cause sickness. By contrast, ingestion of the toxin can be fatal. These matters prompt us to ask a logical question: If someone accidentally ingests some clostridia, will the bacteria synthesize toxin inside the victim's body, thus causing paralysis? This question and the answer to it have led to a chilling new discovery.

Ordinarily, *Clostridium botulinum* cannot grow and multiply inside the human body, so its toxin cannot be synthesized and released. In part, the organism does not grow well because it is an anaerobe, and the healthy human body is not an ideal growth medium for anaerobes. However, there is a more important factor to be considered. Within the human body, and the gut in particular, various types of bacteria compete with one another for their own biological niche. *C. botulinum* is a rather weak competitor and as such is not able to secure a niche; that is, it cannot compete effectively when the human gut has its normal quota of bacteria. If the normal quota is not present, however, matters can be quite different.

There is a time during the human life cycle when few bacteria are present in the gut, when bacterial competition has not reached a furious pitch, and when *C. botulinum* can grow and produce its deadly toxin. Shortly after birth, the human infant's gut is virtually bacteria free. If at this vulnerable time of life, *C. botulinum* bacteria enter and colonize the gut, the outcome can be a tragic case of botulism.

Within the recent past, the first cases of infant botulism have been discovered. Futhermore, the incidence, or at least the ascertainment, of the disease is increasing. Some physicians fear that the incidence of infant botulism may exceed that of the better-known foodborne botulism. They also fear that many previous cases of infant botulism may have been wrongly diagnosed as other serious problems, such as the sudden infant death syndrome known as "crib death."

As its name implies, sudden infant death syndrome occurs rapidly and for no apparent reason. For years, scientists have sought an explanation for this mysterious form of death. With the discovery of infant botulism, the hypothesis arose that some cases of crib death might have been caused by botulinum toxin. This hypothesis is now being carefully examined by many pathologists.

At the moment, medical investigators and public health officials are working vigorously to determine the true incidence of infant botulism. They are also searching for ways to prevent the disease from occurring and ways to treat it when it does occur. Clearly, these concerns are equally germane to foodborne botulism. Whether botulism originates from poisoning or as an infant infection, preventive and curative measures are desperately needed.

The reader will probably be surprised to learn that preventive measures are, at least potentially, already available. There does exist a botulinum toxoid that confers immunity to botulism, but it has not been, and may never be, marketed. The pharmaceutical industry believes that the general public is not strongly motivated to seek immunization against botulism. According to this belief, it would not be cost-effective to develop and market the toxoid because too few people would want to be immunized.

Current research is focused almost exclusively on developing a cure. But even the most optimistic scientist would concede that that is not on the near horizon. For the time being, botulism remains a tragic and often fatal disease for which there is no cure.

*Lance L. Simpson is a pharmacologist on the staff of the College of Physicians and Surgeons of Columbia University.*

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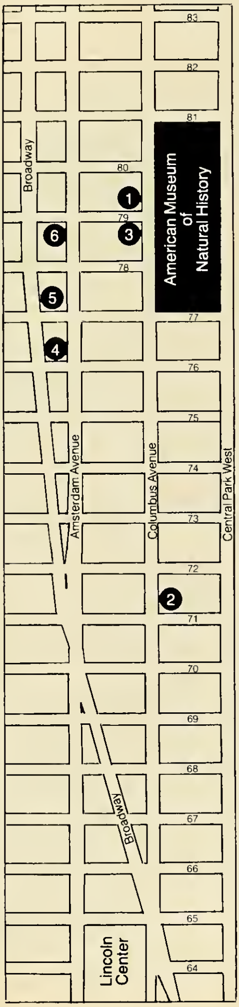
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**This View of Life**

**by Stephen Jay Gould**

# Wallace's Fatal Flaw

*"I hope," wrote Darwin, "you have not murdered . . . your own and my child"*

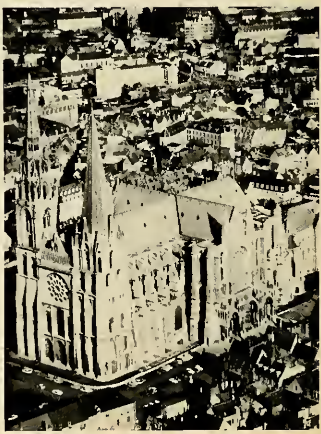
In the south transept of Chartres cathedral, the most stunning of all medieval windows depicts the four evangelists as dwarfs sitting upon the shoulders of four Old Testament prophets—Isaiah, Jeremiah, Ezekiel, and Daniel. When I first saw this window as a cocky undergraduate in 1961, I immediately thought of Newton's famous aphorism—"If I have seen further it is by standing on the shoulders of Giants"—and imagined that I had made a major discovery in unearthing his lack of originality.

Years later, and properly humbled for many reasons, I learned that Robert K. Merton, the celebrated sociologist of science from Columbia University, had devoted an entire book to pre-Newtonian usages of the metaphor (*On the Shoulders of Giants*, Harcourt, Brace and World, 1965). In fact, Merton traces it back to Bernard of Chartres in 1126 and cites several scholars who believe that the windows of the great south transept, installed after Bernard's death, represent an explicit attempt to capture his metaphor in glass.

Although Merton wisely constructs his book as a delightful romp through the intellectual life of medieval and Renaissance Europe, he does have a serious point to make. Merton has devoted much of his work to the study of multiple discoveries in science. He has shown that almost all major ideas arise many times, usually independently and virtually at the same time. Thus, great scientists are embedded in their cultures, not uniquely divorced from them. Most great ideas are "in the air," and several scholars simultaneously wave their nets.

One of the most famous of Merton's "multiples" resides in my own field of evolutionary biology. Charles Darwin, to recount the famous tale briefly, developed his theory of natural selection in 1838 and set it forth in two unpublished sketches of 1842 and 1844. Then, never doubting his theory for a moment, but afraid to expose its revolutionary implications, he proceeded to stew, dither, wait, ponder, and collect data for another fifteen years. Finally, at the virtual insistence of his closest friends, he began to work on his notes, intending to publish a massive tome that would have been four times as long as the *Origin of Species*.

But in 1858 Darwin received a letter and manuscript from a young naturalist, Alfred Russel Wallace, who had independently constructed the theory of natural selection while lying ill with malaria on an island in the Malay



*Chartres cathedral,* The Granger Collection

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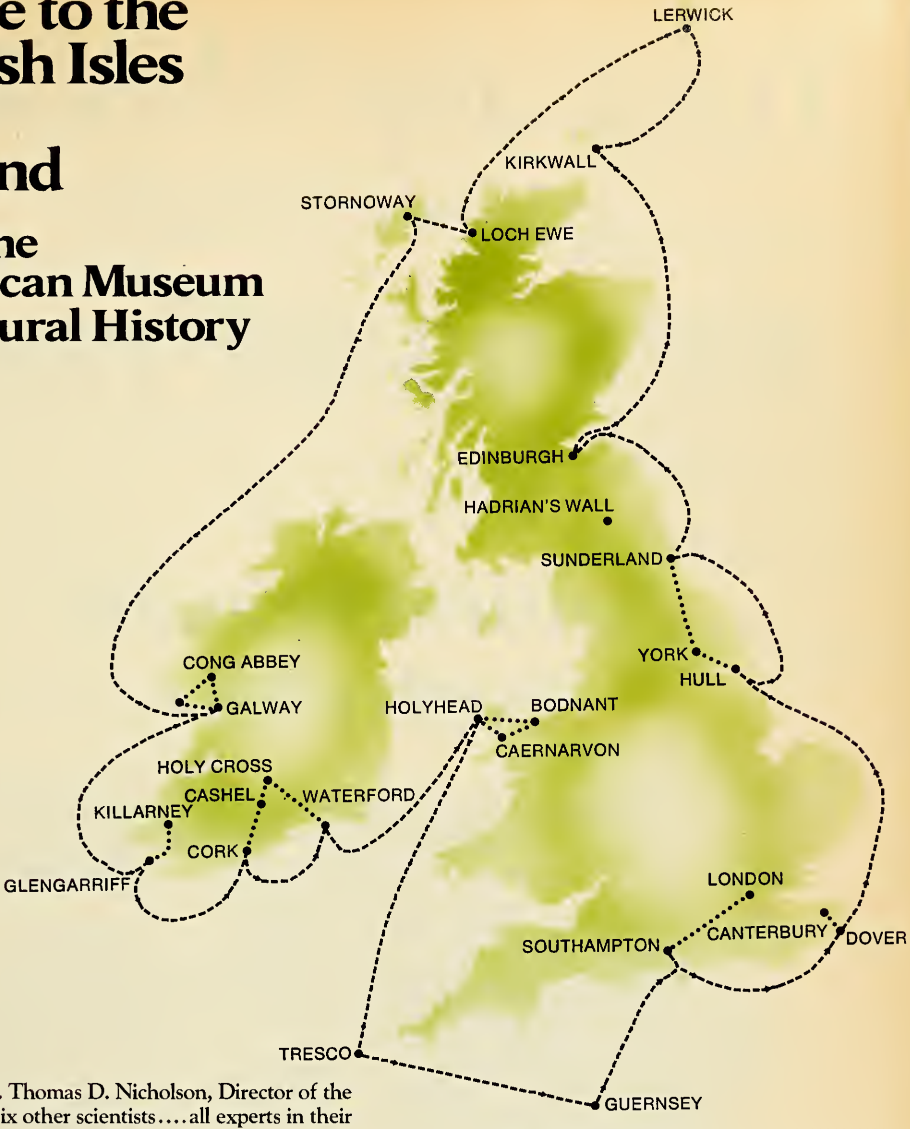

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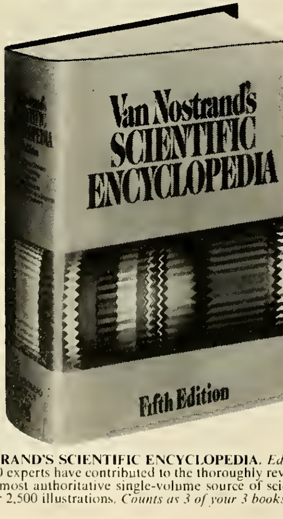

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Archipelago. Darwin was stunned by the detailed similarity. Wallace even claimed inspiration from the same nonbiological source—Malthus's essay on population. Darwin, in great anxiety, made the expected gesture of magnanimity but devoutly hoped that some way might be found to preserve his legitimate priority. He wrote to Lyell: "I would far rather burn my whole book, than that he or any other man should think that I have behaved in a paltry spirit." But he added a suggestion: "If I could honorably publish, I would state that I was induced now to publish a sketch . . . from Wallace having sent me an outline of my general conclusions."

Lyell and Hooker took the bait and came to Darwin's rescue. While Darwin stayed home, mourning the death of his daughter from scarlet fever, they presented a joint paper to the Linnaean Society containing an excerpt from Darwin's 1844 essay, together with Wallace's manuscript. A year later, Darwin published his feverishly compiled "abstract" of the longer work—the *Origin of Species*. Wallace had been eclipsed.

Wallace has come down through history as Darwin's shadow. In public and private, Darwin was infallibly decent and generous to his younger colleague. He wrote to Wallace in 1870:

> I hope it is a satisfaction to you to reflect—and very few things in my life have been more satisfactory to me—that we have never felt any jealousy towards each other, though in one sense rivals.

Wallace, in return, was consistently deferential. In 1864, he wrote to Darwin:

> As to the theory of Natural Selection itself, I shall always maintain it to be actually yours and yours only. You had worked it out in details I had never thought of, years before I had a ray of light on the subject, and my paper would never have convinced anybody or been noticed as more than an ingenious speculation, whereas your book has revolutionized the study of Natural History, and carried away captive the best men of the present age.

This genuine affection and mutual support masked a serious disagreement on what may be the fundamental question in evolutionary theory—both then and today. How exclusive is natural selection as an agent of evolutionary change? Must all features of organisms be viewed as adaptations? Yet Wallace's role as Darwin's subordinate alter ego is so firmly fixed in popular accounts that few students of evolution are even aware that the two men ever differed on theoretical questions. Moreover, in the one specific area where their public disagreement is a matter of record—the origin of human intellect—many writers have told the story backward because they failed to locate this debate in the context of a more general disagreement on the power of natural selection.

All subtle ideas can be trivialized, even vulgarized, by portrayal in uncompromising and absolute terms. Marx felt compelled to deny that he was a Marxist, while Einstein contended with the serious misstatement that he meant to say "all is relative." Darwin lived to see his name appropriated for an extreme view that he never held—for Darwinism has often been defined, both in his day and in our own, as the belief that virtually all evolutionary change is the product of natural selection.

Darwin often complained, with uncharacteristic bitterness, about this misappropriation of his name. He wrote in the last edition of the *Origin* (1872):

> As my conclusions have lately been much misrepresented, and it has been stated that I attribute the modification of species exclusively to natural selection, I may be permitted to remark that in the first edition of this work, and subsequently, I placed in a most conspicuous position—namely, at the close of the Introduction—the following words: "I am convinced that natural selection has been the main but not the exclusive means of modification." This has been of no avail. Great is the power of steady misrepresentation.

England did house a small group of strict selectionists—"Darwinians" in the misappropriated sense—and Alfred Russel Wallace was their leader. These biologists attributed all evolutionary change to natural selection. They viewed each bit of morphology, each function of an organ, each behavior as a product of selection leading to a "better" organism. They held a deep belief in nature's "rightness," in the exquisite fit of all creatures to their environments. In a curious sense, they almost reintroduced the creationist notion of natural harmony by substituting an omnipotent force of natural selection for a benevolent deity.

Darwin, on the other hand, was a consistent pluralist gazing upon a messier universe. He saw much fit and harmony, for he believed that natural selection holds pride of place among evolutionary forces. But other processes work as well, and organisms display an array of features that are not adaptations and do not promote survival directly. Darwin took particular interest in two principles leading to nonadaptive change: (1) Organisms are integrated systems and adaptive change in one part can lead to nonadaptive modifications of other features ("correlations of growth" in Darwin's phrase); (2) An organ built under the influence of selection for a specific role may be able, as a consequence of its structure, to perform many other, unselected functions as well.

Wallace stated the hard, hyperselectionist line—"pure Darwinism" in his terms—in an early article of 1867, calling it "a necessary deduction from the theory of natural selection."

> None of the definite facts of organic selection, no special organ, no characteristic form or marking, no peculiarities of instinct or of habit, no relations between species or between groups of species, can exist but which must now be, or once have been, useful to the individuals or races which possess them.

Indeed, he argued later, any apparent nonutility must only reflect our faulty knowledge—a remarkable argument since it renders the principle of utility impervious to disproof *a priori*:

> The assertion of "inutility" in the case of any organ . . . is not, and can never be, the statement of a fact, but merely an expression of our ignorance of its purpose or origin.

All the public and private arguments that Darwin pursued with Wallace centered upon their differing assessments of the power of natural selection. They first crossed swords on the issue of "sexual selection," the subsidiary process that Darwin had proposed to explain the origin of features that appeared to be irrelevant or even harmful in the usual "struggle for existence" (expressed primarily in feeding and defense), but that could be interpreted as devices for increasing success in mating—elaborate antlers of deer, or tail feathers of peacocks, for example. Darwin proposed two kinds of sexual selection: competition among males for access to females and choice exercised by females themselves. He attributed much of the racial differentiation among modern humans to sexual selection, based upon the different criteria of beauty that arose among various peoples. (His book—*The Descent of Man and Selection in Relation to Sex*

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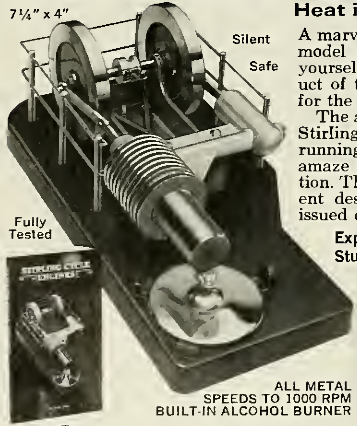

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[1871]—is an amalgam of two works: a long treatise on sexual selection throughout the animal kingdom and a shorter, speculative account of human origins, relying heavily upon sexual selection.)

The notion of sexual selection is not really contrary to natural selection, for it is just another route to the Darwinian imperative of differential reproductive success. But Wallace disliked sexual selection for three reasons: it compromised the generality of that peculiarly nineteenth-century view of natural selection as a battle for life itself, not merely for copulation; it placed altogether too much emphasis upon the "volition" of animals, particularly in the concept of female choice; and most importantly, it permitted the development of numerous, important features that are irrelevant, if not actually harmful, to the operation of an organism as a well-designed machine. Thus, Wallace viewed sexual selection as a threat to his vision of animals as works of exquisite craftsmanship, wrought by the purely material force of natural selection. (Indeed, Darwin had developed the concept largely to explain why so many differences among human groups are irrelevant to survival based upon good design, but merely reflect the variety of capricious criteria for beauty that arose for no adaptive reason among various races. In the end, Wallace did accept sexual selection based upon male combat as close enough to the metaphor of battle that controlled his concept of natural selection. But he firmly rejected the notion of female choice and distressed Darwin with his speculative attempts to attribute all features based upon it to the adaptive action of natural selection.)

As he prepared the *Descent of Man*, Darwin wrote to Wallace in 1870: "I grieve to differ from you, and it actually terrifies me and makes me constantly distrust myself. I fear we shall never quite understand each other." He struggled to understand Wallace's reluctance and even to accept his friend's faith in unalloyed natural selection: "You will be pleased to hear," he wrote to Wallace,

> that I am undergoing severe distress about protection and sexual selection; this morning I oscillated with joy towards you; this evening I have swung back to [my] old position, out of which I fear I shall never get.

But the debate on sexual selection was merely a prelude to a much more serious and famous disagreement on that most emotional and contentious subject of all—human origins. In short, Wallace, the hyperselectionist, the man who had twitted Darwin for his unwillingness to see the action of natural selection in every nuance of organic form, halted abruptly before the human brain. Our intellect and morality, Wallace argued, could not be the product of natural selection; therefore, since natural selection is evolution's only way, some higher power—God, to put it directly—must have intervened to construct this latest and greatest of organic innovations.

If Darwin had been distressed by his failure to impress Wallace with sexual selection, he was positively aghast at Wallace's abrupt about-face at the finish line itself. He wrote to Wallace in 1869: "I hope you have not murdered too completely your own and my child." A month later, he remonstrated: "If you had not told me, I should have thought that [your remarks on Man] had been added by some one else. As you expected, I differ grievously from you, and I am very sorry for it." Wallace, sensitive to the rebuke, thereafter referred to his theory of human intellect as "my special heresy."

The conventional account of Wallace's apostasy at the brink of complete consistency cites a failure of courage to take the last step and admit man fully into the natural system—a step that Darwin took with commendable fortitude in two books, the *Descent of Man* and *The Expression of the Emotions in Man and Animals* (1872). Thus, Wallace emerges from most historical accounts as a lesser man than Darwin for one (or more) of three reasons, all related to his position on the origins of human intellect: for simple cowardice; for inability to transcend the constraints of culture and traditional views of human uniqueness; and for inconsistency in advocating natural selection so strongly (in the debate on sexual selection), yet abandoning it at the most crucial moment of all.

I cannot analyze Wallace's psyche and will not comment on his deeper motives for hewing to the unbridgeable gap between human intellect and the behavior of mere animals. But I can assess the logic of his argument and recognize that the traditional account is not only incorrect, but precisely backward. Wallace did not abandon natural selection at the human threshold. Rather, it was his peculiarly rigid view

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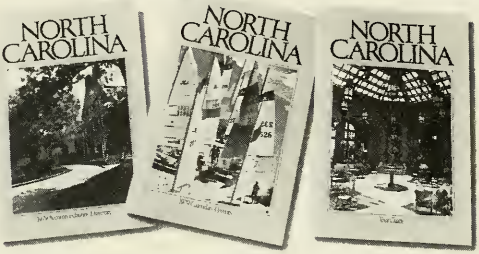

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of natural selection that led him, quite consistently, to reject it for the human mind. His position never varied—natural selection is the only cause of major evolutionary change. His two major debates with Darwin—sexual selection and the origin of human intellect—represent the same argument, not an inconsistent Wallace championing selection in one case and running from it in the other. Wallace's error on human intellect arose from the inadequacy of his rigid selectionism, not from a failure to apply it. And his argument repays our study today, since its flaw remains as the weak link in many of the most "modern" evolutionary speculations of our current literature. For Wallace's rigid selectionism is much closer than Darwin's pluralism to the attitude embodied in our favored theory today, which, ironically in this context, goes by the name of Neo-Darwinism.

Wallace advanced several arguments for the uniqueness of human intellect, but his central claim begins with an extremely uncommon position for his time, one that commands our highest praise in retrospect. Wallace was one of the few nonracists of the nineteenth century. He really believed that all human groups had innately equal capacities of intellect. Wallace defended his decidedly unconventional egalitarianism with two arguments, anatomical and cultural. He claimed, first of all, that the brains of "savages" are neither much smaller nor more poorly organized than our own:

> In the brain of the lowest savages, and, as far as we know, of the prehistoric races, we have an organ . . . little inferior in size and complexity to that of the highest type.

Moreover, since cultural conditioning can integrate the rudest savage into our most courtly life, the rudeness itself must arise from a failure to use existing capacities, not from their absence:

> It is latent in the lower races, since under European training native military bands have been formed in many parts of the world, which have been able to perform creditably the best modern music.

Of course, in calling Wallace a nonracist, I do not mean to imply that he regarded the cultural practices of all peoples as equal in intrinsic worth. Quite the contrary. Wallace, like most of his contemporaries, was an ardent cultural chauvinist who never doubted the evident superiority of European ways. He may have been bullish on the

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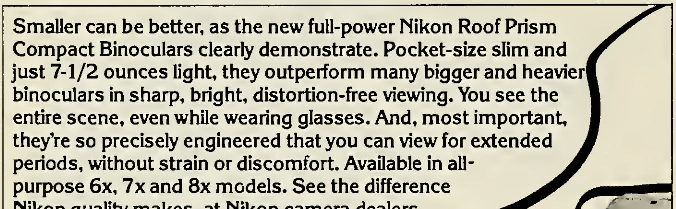

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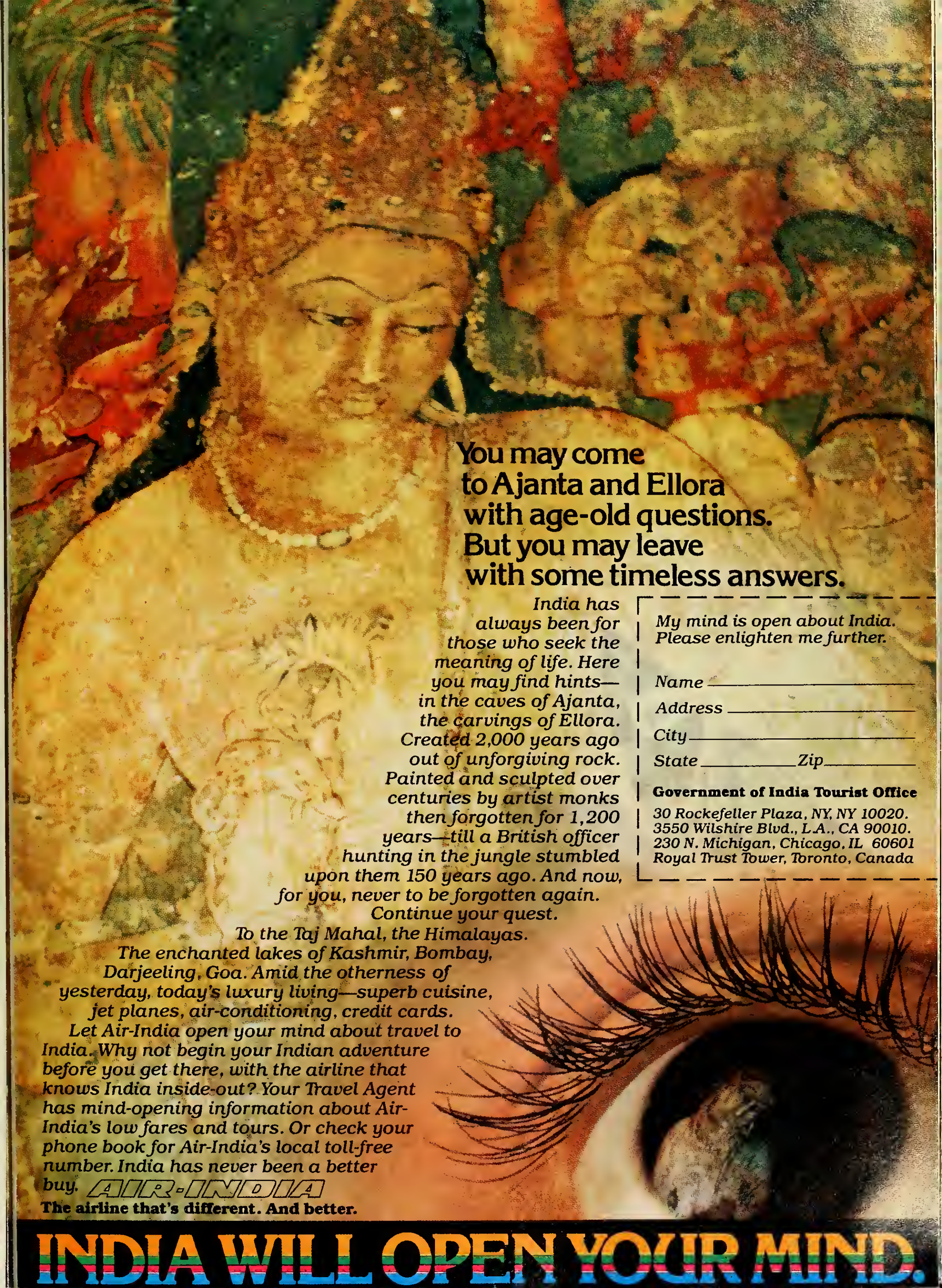

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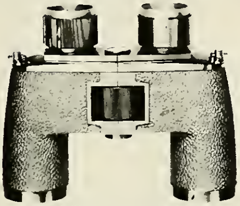

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capability of savages, but he certainly had a low opinion of their life, as he mistook it:

> Our law, our government, and our science continually require us to reason through a variety of complicated phenomena to the expected result. Even our games, such as chess, compel us to exercise all these faculties in a remarkable degree. Compare this with the savage languages, which contain no words for abstract conceptions; the utter want of foresight of the savage man beyond his simplest necessities; his inability to combine, or to compare, or to reason on any general subject that does not immediately appeal to his senses.

Hence, Wallace's dilemma: all savages, from our actual ancestors to modern survivors, had brains fully capable of developing and appreciating all the finest subtleties of European art, morality and philosophy; yet they used, in the state of nature, only the tiniest fraction of that capacity in constructing their rudimentary cultures, with impoverished languages and repugnant morality.

But natural selection can only fashion a feature for immediate use. The brain is vastly overdesigned for what it accomplished in primitive society; thus, natural selection could not have built it:

> A brain one-half larger than that of the gorilla would . . . fully have sufficed for the limited mental development of the savage; and we must therefore admit that the large brain he actually possesses could never have been solely developed by any of those laws of evolution, whose essence is, that they lead to a degree of organization exactly proportionate to the wants of each species, never beyond those wants. . . . Natural selection could only have endowed savage man with a brain a few degrees superior to that of an ape, whereas he actually possesses one very little inferior to that of a philosopher.

Wallace did not confine this general argument to abstract intellect, but extended it to all aspects of European "refinement," to language and music in particular. Consider his views on "the wonderful power, range, flexibility, and sweetness of the musical sounds producible by the human larynx, especially in the female sex."

> The habits of savages give no indication of how this faculty could have been developed by natural selection, because it is never required or used by them. The singing of savages is a more or less monotonous howling, and the females seldom sing at all. Savages certainly never choose their wives for fine voices, but for rude health, and strength, and physical beauty. Sexual selection could not therefore have developed this wonderful power, which only comes into play among civilized people. It seems as if the organ had been prepared in anticipation of the future progress in man, since it contains latent capacities which are useless to him in his earlier condition.

Finally, if our higher capacities arose before we used or needed them, then they cannot be the product of natural selection. And if they originated in anticipation of a future need, then they must be the direct creation of a higher intelligence: "The inference I would draw from this class of phenomena is, that a superior intelligence has guided the development of man in a definite direction, and for a special purpose." Wallace had rejoined the camp of natural theology. Darwin remonstrated, but failed to budge his partner.

The fallacy of Wallace's argument is not a simple unwillingness to extend evolution to humans, but rather the hyperselectionism that permeated all his evolutionary thought. For if hyperselectionism is valid—if every part of every creature is fashioned for and only for its immediate use—then Wallace cannot be gainsaid. The earliest Cro-Magnon people, with brains bigger than our own, produced stunning paintings in their caves, but did not write symphonies or build computers. All that we have accomplished since then is the product of cultural evolution based on a brain of unvarying capacity. In Wallace's view, that brain could not be the product of natural selection, since it could always do so much more than it did in its original state.

But hyperselectionism is not valid. It is a caricature of Darwin's subtler view, and it both ignores and misunderstands the nature of organic form and function. Natural selection may build an organ "for" a specific function or group of functions. But this purpose need not fully specify the capacity of a structure. Objects designed for definite purposes can, as a result of their structural complexity, perform many other tasks as well. A factory may install a computer only to issue the monthly pay checks, but such a machine can also analyze the election returns or whip anyone (or at least perpetually tie them) in tick-tack-toe. Our large brains may have originated for some set of necessary skills in gathering food, socializing, or whatever; but these skills do not exhaust the limits of what such a complex machine can do. Fortunately for us, those limits in-

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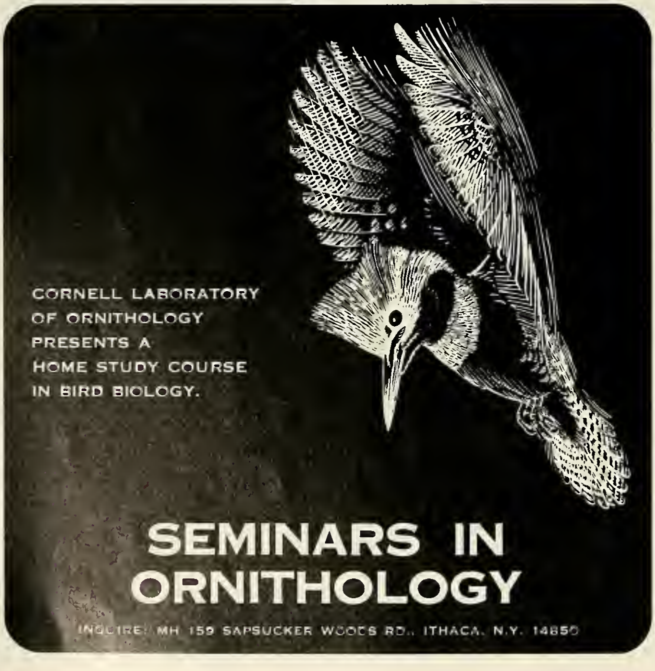

clude, among other things, an ability to write—from shopping lists for all of us to grand opera for a few. And our larynx may have arisen for a limited range of articulated sound needed to coordinate social life. But its physical design permits us to do more with it—from singing in the shower for all to the occasional diva.

Hyperselectionism has been with us for a long time in various guises, for it represents the late-nineteenth-century's scientific version of the myth of natural harmony—all structures well designed for a definite purpose. It is, indeed, the vision of foolish Dr. Pangloss, so vividly satirized by Voltaire in *Candide*—"all is for the best in the best of all possible worlds." As the good doctor said in a famous passage, which predated Wallace by a century, but captures the essence of what is so deeply wrong with his argument:

> Things cannot be other than they are. . . . Everything is made for the best purpose. Our noses were made to carry spectacles, so we have spectacles. Legs were clearly intended for breeches, and we wear them.

Nor is Panglossianism dead today—not when so many books in the pop literature on human behavior state that we evolved our big brain for hunting, then trace all our current ills to limits of thought and emotion supposedly imposed by such a mode of life.

Ironically then, Wallace's hyperselectionism led right back to the basic belief of an earlier creationism that it meant to replace—a faith in the rightness of things, a definite place for each object in an integrated whole. As Wallace wrote, quite unfairly, of Darwin:

> He whose teachings were at first stigmatized as degrading or even atheistical, by devoting to the varied phenomena of living things the loving, patient, and reverent study of one who really had faith in the beauty and harmony and perfection of creation, was enabled to bring to light innumerable adaptations, and to prove that the most insignificant parts of the meanest living things had a use and a purpose.

I do not deny that nature has its harmonies. But structure also has its latent capacities. Built for one thing, it can do others—and in this flexibility lies both the messiness and the hope of our lives.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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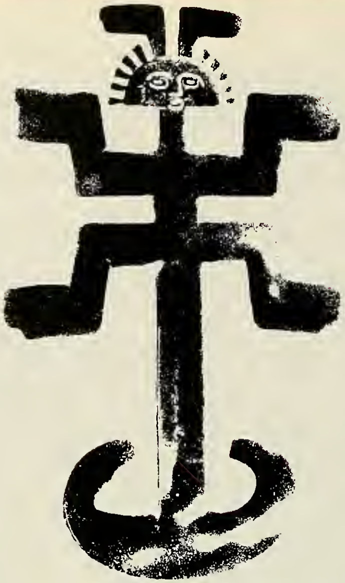

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The national tour of "Gold of El Dorado" is sponsored by Chemical Bank, with additional support from the National Endowment for the Humanities and the Federal Council on the Arts and Humanities.

Gold of El Dorado: November 13, 1979, through March 18, 1980

The Museum, as always, will endeavor to give special treatment to its nearly half million dedicated members. Tickets, which allow members and their guests priority entrance to the exhibition, have been mailed to all members in the Greater New York metropolitan region. Members living outside the metropolitan region who would like to see this exhibition should write us at

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Gulf

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*"If any oil gets into the water, the Bay Skimmer can pick it up fast."*

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# Powerful Magazine

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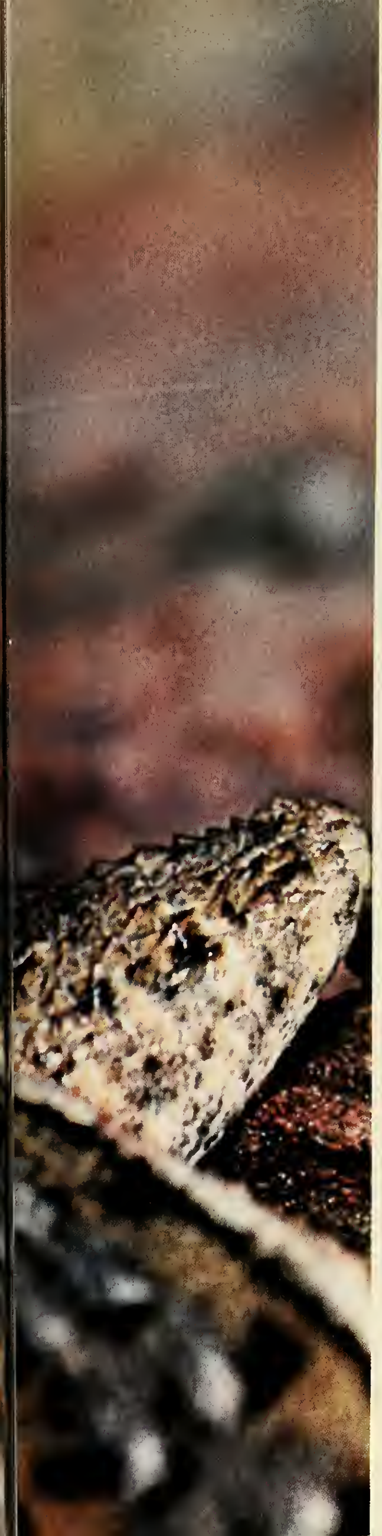


# Desert Shrewd

*To survive in the desert, a tiny mammal must venture forth at night, conserve its water, and eat like mad*

**by Stan L. Lindstedt and James H. Jones**
**photographs by Raymond A. Mendez**

The deserts of the southwestern United States test, in a number of ways, an animal's ability to survive. The parched land has little or no free water, and air temperatures during summer days may exceed 120°F. Only animals that can tolerate or avoid such heat, and that are especially adept at conserving water, survive.

Paradoxically, among the desert dwellers there lives an animal whose closest relatives are found almost exclusively in lush, moist habitats. The paradox is deepened by this animal's size and diet, which suggest a minimal tolerance of high temperatures and an extreme need for water. It is the smallest mammal living in any of the world's deserts—the desert shrew.

This tiny mammal is found throughout the southwestern United States and northern Mexico, inhabiting parts of the Sonoran, Chihuahuan, Mojave, and Great Basin deserts. Although they may be abundant in some areas, desert shrews are rarely encountered by biologists. Much of the information about their distribution has come, not from firsthand observations, but from bones recovered in owl pellets. In addition to being the smallest desert mammal, the desert shrew is also one of the world's smallest homoiotherms (animals that maintain a constant body temperature). The animal measures only about one and a half inches in length (about half of which is tail) when fully grown, and ranges in weight from less than three grams (the weight of a penny) to five grams (the weight of a nickel).

Desert shrews are born during the summer in litters of three to six. Naked, pink, and about the size of honeybees, newborns grow rapidly, and after two weeks their combined weight may be twice that of their mother. For her size, the mother produces milk at a rate that must be a mammalian record—and she does it without drinking water. Two to three weeks after birth, the babies' diet is supplemented in a manner formerly believed to be unique, among mammals, to canids. Food is brought back to the nest and regurgitated into the mouths of the young. The shrews reach adult size in four to five weeks and are out of the nest and on their own by the time the first cold nights of fall arrive.

Shrews are in the mammalian order Insectivora. Because their diet includes great numbers of insects, they consume large amounts of protein. The waste product of protein digestion is nitrogen, which is excreted in urine as urea. If their kidneys could concentrate urine no more than the kidneys of other shrews, desert shrews would require several times their actual daily water intake just to relieve themselves of urea.

While the desert shrew's potential for urinary water loss is great, other water losses could be even greater. To maintain a constant body temperature

*Gnawing on the tail of a bunch grass lizard, a desert shrew begins to feast on prey larger than itself. The lizard was asleep under an agave, where the shrew discovered and dispatched it.*

of about 99°F, they must use some water for evaporative cooling. Unless heat is lost by the evaporation of water, the body temperature of an animal in a hot environment will increase until it equals that of its surroundings. In some mammals, such as humans, evaporative cooling takes the form of sweating; in shrews and many other mammals it is accomplished by panting. As long as enough water is available, evaporative cooling can maintain body temperature within tolerable limits.

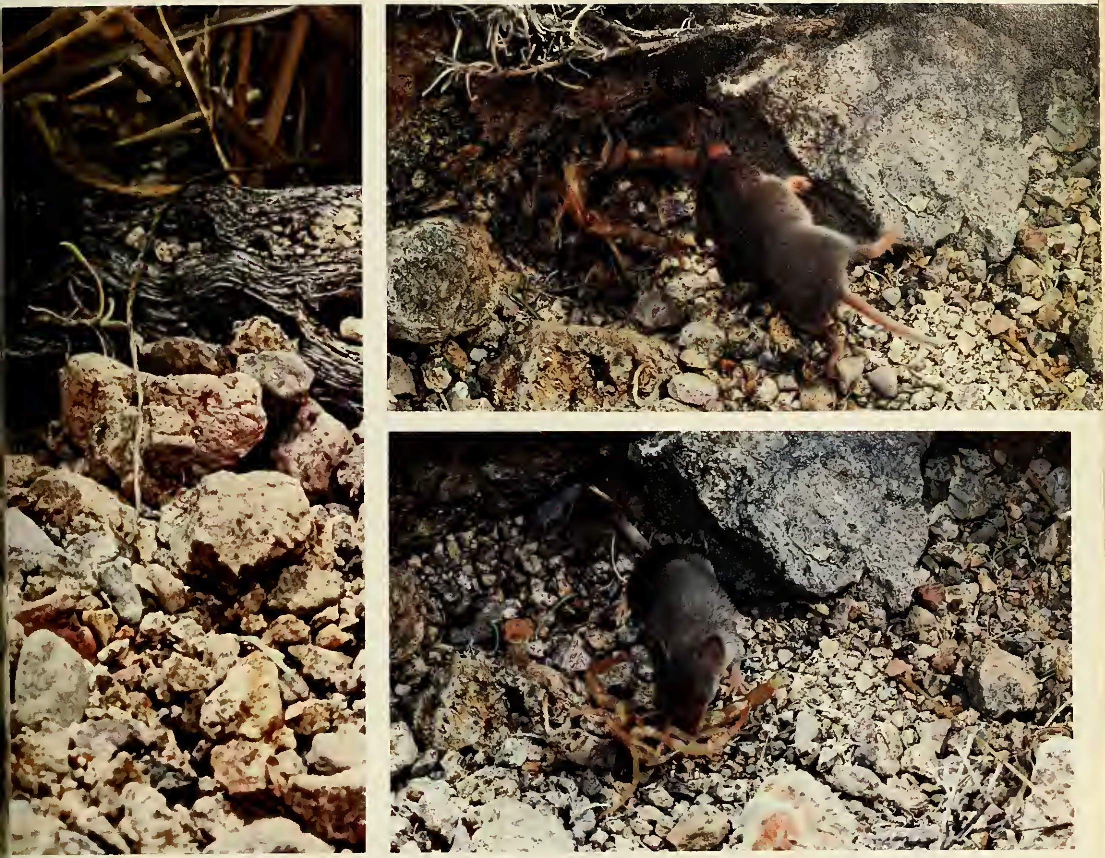
The rate of heat exchange is proportional both to the difference in temperature between the animal and its environment and to the body size of the animal. Just as a spoonful of soup heats or cools more rapidly than a bowlful, so the body temperatures of the smallest animals are most sensitive to the thermal environment surrounding them. An animal or object exchanges heat with its surroundings at a rate proportional to its surface area, while its capacity to store heat is proportional to its mass. The smallest animals have a large area for heat exchange and a small body mass; therefore they heat and cool rapidly. An animal with a small body mass, such as a shrew, must evaporate water at a much faster rate (for its size) than a larger-bodied animal when both are in the same hot environment.

This relationship between body size and the rate of heat exchange is also a liability for small animals in the cold—a smaller body cools faster when the temperature is below body temperature. As a result, smaller animals produce more heat per unit body mass than larger animals. If it had the same metabolic rate as a cow, an animal the size of a one-inch shrew would need eight inches of fur to keep warm at room temperature; conversely, a cow's body temperature would exceed the boiling point of water if it produced metabolic heat as rapidly as a shrew.

To maintain such a high rate of metabolism, shrews must consume a great deal of food for fuel. This high food intake is the basis for the legend that a "shrew eats its own weight in food each day." In fact, many do. However, the shrew's high metabolic rate, necessary for it to keep warm in low air temperatures, becomes a liability when the temperature is high. A shrew in a hot desert faces overheating when heat produced by its high metabolism is coupled with heat gained from the environment.

Its metabolism could cause yet another problem for the desert shrew—an increase in all of the body's functions, including respiration rates. Every rapid breath of dry desert air is saturated with water vapor from the moist lung surface. If all of this water were lost with each exhalation, the total water loss due to respiration would be considerable.

The potential water loss from all of



*Attacking a giant hairy scorpion, a desert shrew rushes in to bite the venomous arachnid, which raises its tail in a typical defense posture, left. Lashing out with its tail, the scorpion tries to sting its attacker, top. The shrew jumps easily out of the way and wins the battle by biting through the scorpion's tail, bottom.*

these sources would appear to vastly exceed the amount of water available to this nondrinking shrew through its insect diet. Since shrews are otherwise restricted to moist habitats that supply them with abundant water, desert shrews possess unique adaptations that allow them to survive in the dry habitat. Results from studies completed recently at the University of Arizona suggest how they surmount seemingly impossible obstacles.

Shrews do not construct burrows or use those of other animals, hence they are unable to avoid environmental extremes the way other small desert rodents do. Instead, they use grasses and other available vegetation to build nests that insulate them against severe external temperatures, and in so doing they conserve water. These nests, as small inside as one by one and a half inches, are frequently built inside pack rat houses or in leaf litter beneath dead agaves. Consequently, these shrews live in microhabitats that are mild relative to outside conditions. By this strategy, the desert shrew effectively exploits its tiny size to avoid an environmental stress that many larger animals must confront directly.

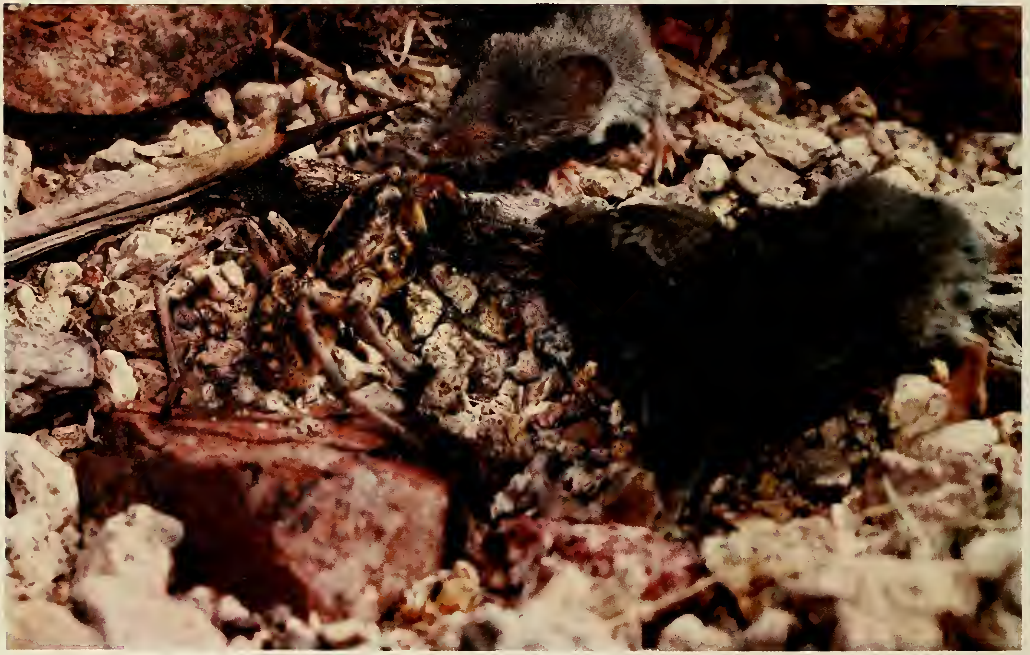
The desert shrew also conserves water by restricting most of its activities to the night. This behavior is uncommon among shrews, which usually hunt both day and night since they can starve to death in as few as four hours. The desert shrew's senses reflect its primarily nocturnal existence; although its vision is poor, its long nose and large ears appear to be extremely sensitive. In fact, the desert shrew has such well-developed external ears (rare among shrews) that it is occasionally referred to as the "eared shrew." It may also have some rudimentary ability to echolocate prey, utilizing high-frequency squeaks similar to the sophisticated sonar of bats, their near relatives. The ears probably also act as heat radiators, increasing the surface area for heat loss when the shrew is hot and in a suitable location to lose heat by this means.

Voracious and energetic hunters, desert shrews depend primarily on their acute hearing to locate prey. A shrew may leave its nest to forage and eat many times during the night, attacking almost any insect (including cockroaches, moths, grasshoppers, and grubs), arachnid, lizard, or rodent small enough for it to kill. Prey small enough for the shrew to kill is frequently larger than the shrew itself. If it comes across several insects at once, the desert shrew will dash about killing or incapacitating all of them and will stockpile the prey in its nest before eating. Desert shrews paralyze insects by carefully crushing their heads without killing them. Then, when they need to refuel after a few hours, their insect food is still alive and, more importantly, has lost little of the valuable moisture that would have been lost if the exoskeleton had been damaged. Shrews take the largest or most heavily armored insects by first biting off their legs, before delivering a head-crushing bite. With enough prey collected in the nest at night, the shrew has no need to expose itself to daytime heat.

Even though they manage to avoid the most extreme heat by staying in their nests, desert shrews still face a water shortage. An insect diet provides some water, but for desert shrews the key to survival is conserving what little water is available by using some specialized physiological adaptations.

The shrew maintains a positive water balance by considerably reducing two major avenues of water loss—urine and respiration. While its rapid breathing rate tends to increase water losses, a substantial fraction of the water vapor that would otherwise be exhaled is reclaimed through a remarkable arrangement of blood and air flow inside the desert shrew's nose. Inhaled air is warmed to body temperature and saturated with water vapor from the moist nasal walls. Exhaled air is cooled as it passes along the narrow nasal passage in the opposite direction to blood flow in the walls of the nose. This blood, previously cooled at the skin and nose surfaces before flowing along the nasal passage, absorbs heat from the exhaled air, thereby cooling it. As the air cools, much of its water vapor condenses on the walls of the nasal passage, just as dew and fog form when

*With large insects such as this praying mantis, a desert shrew first bites off enough legs to immobilize the victim. A head-crushing bite is the* coup de grâce.



warm, moist air cools during the night. The net result of this "countercurrent heat exchanger" is that the cooler exhaled air contains far less water vapor than if it were exhaled at body temperature.

Respiratory water loss is further reduced in these animals because they take fewer breaths relative to other shrews. Their low resting metabolic rate—the lowest of all shrew species—decreases passive respiratory water losses. Because they produce less internal heat, desert shrews need less water for evaporative cooling. Consequently, they can survive in air temperatures over 100°F, heat loads that would soon be fatal for other shrew species.

The shrew's other major avenue for potential water loss is through the urine because it must excrete a large amount of nitrogenous wastes. However, urinary water loss in the desert shrew is also reduced. By concentrating far more urea in the urine than most other mammals, the desert shrew saves valuable water. Urea is concentrated by the same physical principle that conserves water in the nose—a countercurrent system. However, in the kidney, instead of heat being exchanged, urea is concentrated along the length of extremely long tubes (nephrons), and the final urine is four times more concentrated than that of humans. Since only a few drops of concentrated urine are sufficient to remove all of the shrew's nitrogenous wastes each day, the result is a substantial savings of water for the animal. These few drops are used to cement the feces together in a characteristic fashion. A useful indicator that a desert shrew nest is nearby is one of these fairly conspicuous defecatoria, which are always in the immediate vicinity of the nest.

Another severe challenge to this animal's survival is presented by the often unpredictable periods of food scarcity. Birds can escape these periods by migration, and many desert rodents survive by hibernating or feeding on seed stores. Shrews, however, are not known to hibernate and they cannot store their perishable insect food for long. During the Sonoran Desert's two dry seasons, late spring and late fall, temperatures are mild, but insect abundance is often low. At those times, desert shrews spend the daytime hours in a state of torpor, during which their body temperature thermostat is reset about 20°F below its normal level. This "regulated hypothermia," unique among North American insectivores, allows the shrew to maintain a reduced metabolic rate and stretch its available energy reserves up to five times longer than would otherwise be possible.

Physiological and behavioral frugality have allowed the desert shrew, a member of a mammalian family normally restricted to cool, moist habitats, to survive in the hot North American deserts. Energy metabolism, water loss, and daytime activity are all lower in the desert shrew than in any other shrew species. Maintaining a strict economy of water and energy has allowed it to successfully exploit an environment that would be lethal to its closest relatives. The desert shrew's survival is a prime example of the need for conservation in an environment where resources are limited. ☐

*Two sibling shrews mount an attack against a wolf spider, above. They have already bitten off several legs, and the end is in sight. The spiders are virtually defenseless against these predators. Right, one of the shrews carries off the dead spider to its nest for later consumption. (The shrews are so fast that lights firing at 1/3,000 second cannot stop the action.)*

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# Spider and Fly Play Cat and Mouse

*"Come into my parlor," said the spider to the fly. The fly did—and had an excellent meal*

**by William G. Eberhard**

The spider and the fly—the bumbling, defenseless victim pitted in a hopeless struggle against a stealthy, overpowering foe. This popular piece of folklore is indeed an accurate picture of the relationship between many spiders and their insect prey. Nevertheless, spiders and insects have coexisted for more than 250 million years, with spiders constantly evolving to be more effective predators, and insects evolving defenses against them. Not surprisingly, with that much time and the large numbers of species involved, some unusual and complicated relationships have arisen. Recent research has uncovered a few of them.

Consider, for example, the case of the fly on the silken trapeze. When most spiders move about, they lay nonsticky trail threads behind them as safety lines. As a result, foliage where spiders have been active acquires a number of loosely strung threads, which accumulate until broken by strong winds or rain. Observing such a site at night, one can see that many of these deserted lines have tiny insects clinging to them. Most are flies of the gall gnat family (Cecidomyiidae), but representatives of at least seven other fly families, along with occasional small wasps and moths, also use the tiny trapezes. The insects' styles vary: some hold on securely with all six legs, some hang head down like bats or hang on the broken end of a thread, some hold on with their two front legs and spread the others wide, and some hold a line and copulate at the same time. Huge numbers of flies have been found hanging on spider lines. Enrique Lahmann and Claudia Zuñiga of the Universidad de Costa Rica found more than 500 flies on lines along the edge of a short stretch of trail and calculated that an average of about four flies were clinging to each three feet of spider thread; in just an acre of forest there must be times when tens or perhaps hundreds of thousands of flies are suspended on lines every night.

The significance of these acrobatics becomes clear with the realization that as perches the silk threads are nearly ideal defensive sites. There the flies can rest and avoid contact with twigs and leaves on which predators such as ants and wandering spiders prowl. If a spider does come out on a line, it gives a resting fly ample, though inadvertent, warning by vibrating the line, and the fly leaves. Many flies have even developed a special defensive behavior associated with the lines. When disturbed, they buzz their wings in short bursts; this causes the line to swing back and forth, and presumably makes them more difficult targets for potential predators.

Thus a number of flies have developed a defense against spiders by utilizing the spiders' own discarded silk. How flies can distinguish safe, nonsticky trail lines from the sticky threads in webs is not known. I have seen flies perching on the nonsticky support lines right at the edges of occupied webs; somehow they avoided getting entan-

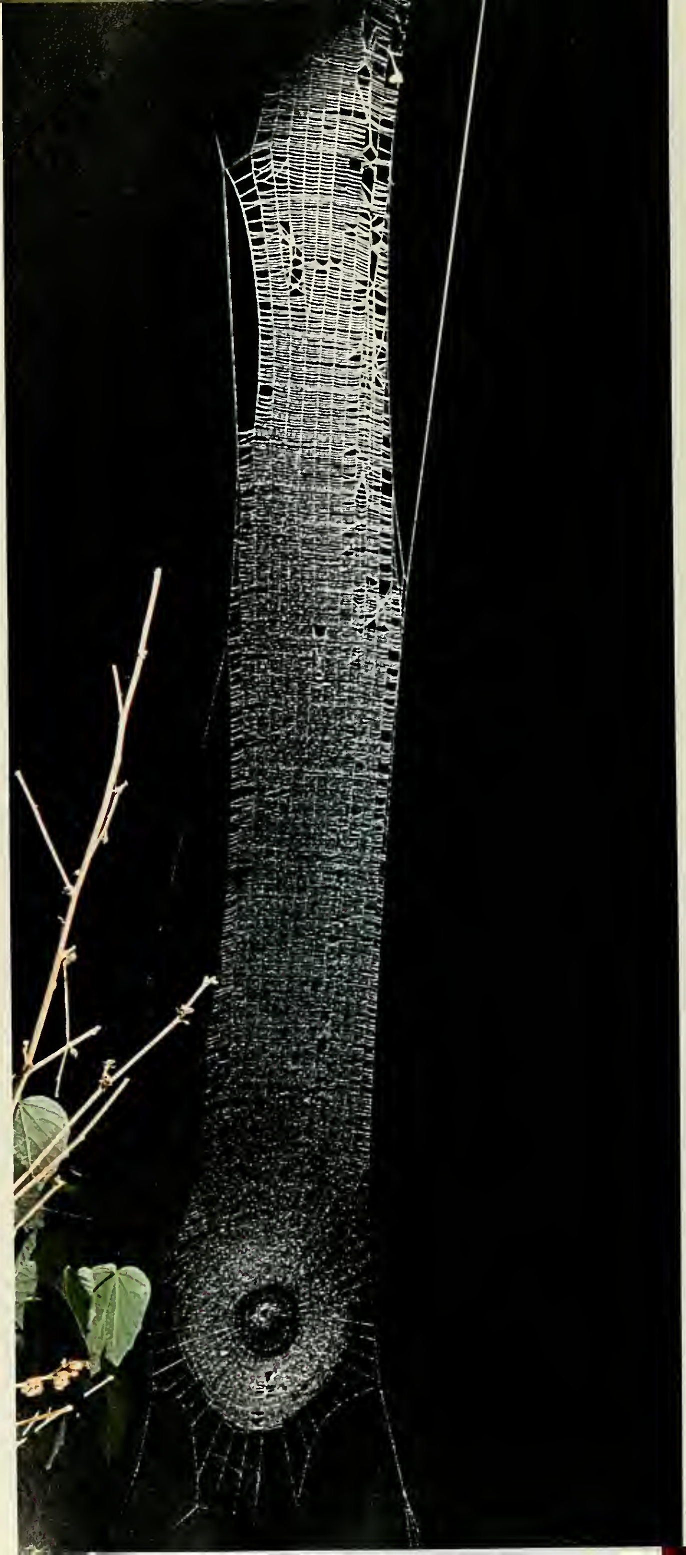
*An orb-weaving spider prepares to eat an enshrouded moth. Such webs are not well designed for catching moths, because a moth's detachable scales often stick to the web while the moth falls free.*

S.J. Krasemann; Peter Arnold

gled in the sticky central portion only a few inches away. A mistake could mean quick death, so the flies must be able to consistently make the correct choice or the silken trapeze habit would not have evolved.

Flies are not the only insects that have found protection by lodging with spiders. Mike Robinson of the Smithsonian Tropical Research Institute found that in New Guinea pyralid moths rest by day on nonsticky lines in the webs of the giant wood spider, *Nephila maculata.* This huge orb weaver, large enough to be roasted and eaten by New Guineans, builds large webs of very strong silk. There are instances of birds being trapped for hours in these webs, and experienced birds carefully avoid known web locations. Moths resting on such webs thus probably gain additional protection against insectivorous birds that will not risk predatory forays so close to the dangerous spider web.

Some insects have gone a stage further in their relationships with spiders and have become active food robbers. For instance, some species of the dance fly family, Empididae, hover slowly near orb webs along the edges of tropical streams and carefully land on small insects that have become entangled in webs but that are too tiny to draw the spider's attention. Recently, Randy Thornhill of the University of New Mexico has found that another group of insects—the scorpion flies, or Mecoptera—also make a habit of landing in the webs of spiders to steal prey trapped there. Large insects, scorpion flies cannot go unnoticed by the spider being robbed. Instead, they regurgitate a special liquid that serves a dual purpose: it repels the spider when it comes close to investigate, and permits the scorpion fly to disentangle itself from the sticky glue on the web's threads. This technique is dangerous, however, since spider attacks sometimes succeed, and Thornhill estimates that one of the major causes of scorpion fly mortality is predation by web-building spiders.



*Ladder webs are ideal for catching moths. A moth flying into the upper part of the web would be stripped of so many scales as it tumbled downward that it would eventually become trapped near the bottom.*

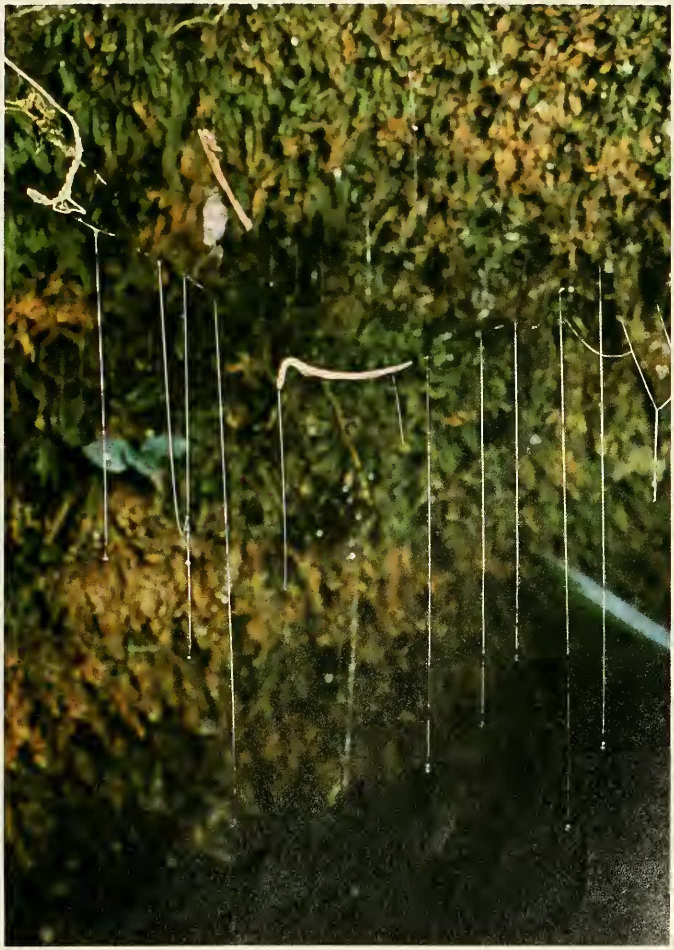
Mark Stowe

Other groups of flies have evolved even more effective tactics. One species of the family Chloropidae can be found during the day resting near an orb weaver that hides off its web in a curled leaf. When prey lands in the web, the spider rushes out, bites it and wraps it in silk, then carries it back to its retreat to feed in relative safety. But as soon as the spider returns with such a food bundle, the flies begin to edge in closer and closer. Their stealthy, hesitant movements remind one of the childhood game "red light, green light." When they get close to their goal, each fly unfolds a long sucking proboscis, and sticks it gently into the prey. After a minute or two of sucking, the fly walks away with its abdomen bloated, leaving the spider with its diminished meal.

This kind of robbery is brought to perfection by some other flies related to fruit flies. These, which were studied by Robinson, live with large orb weavers that sit at the center of their webs during the day. Some flies wait on the web, and others actually sit right on the dorsal part of the spider's body where the spider cannot brush them off. These flies do not have piercing mouthparts, but feed by taking advantage of the spider's method of eating (no solid food is swallowed; instead digestive juices are poured into the prey, and when its tissues have been broken down, the nutrient-rich broth is sucked up). The flies wait until the prey has been partially digested, then dart down off the spider's back, suck up a quick meal, and climb back on again. An Australian species of this group has become so closely adapted to the spider that in addition to robbing its host, the fly cleans it after its meals, carefully mopping off the spider's mouth and fangs and throwing in the extra service of cleaning around its anus after it defecates.

Moths are not outdone by flies when it comes to odd and specialized relationships with spiders. Robinson has found moth caterpillars living inside the giant colonies of the social cobweb spider, *Anelosimus eximus*. The colonial webs of this species sometimes reach several cubic yards, the size of an average room, and they persist for many years in favorable locations. The pyralid caterpillars living in the web are never very numerous, but they move about untroubled by the spiders, which stage devastating mass attacks on any other moving objects. The caterpillars live entirely on the undigested hard parts of the spiders' prey. Since the spiders do not have chewing mouthparts, they cannot cut up such cuticular material, but the moth larvae can, and their role is essentially that of scavengers. In an experimentally contrived situation, one caterpillar did attack a live insect before the spiders detected its presence, but this may not happen in nature.

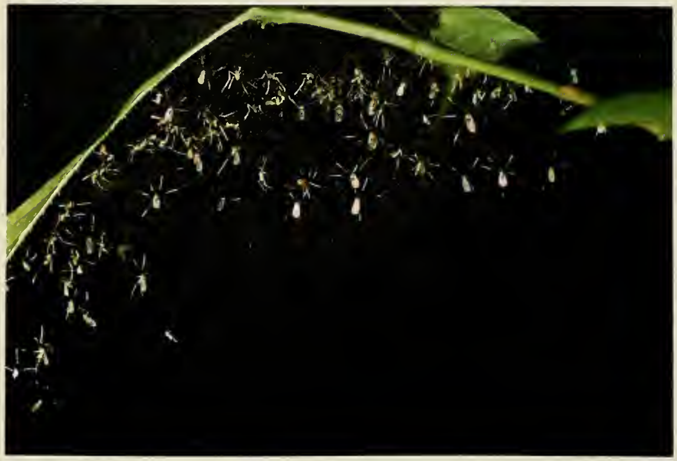
Perhaps the ultimate in role switching is displayed by flies that make webs themselves. These are actually larvae of the fungus gnat family, Mycetophilidae, and they spin webs consisting of numerous sticky lines hanging from a few nonsticky horizontal threads where the larvae crawl. These sticky curtains serve to trap tiny flying insects, which are then reeled in and eaten by the larvae. In one cave-dwelling species from New Zealand the larvae produce light, thus luring the prey to its death. These webs are inferior to spider webs because the sticky lines swing free and easily tangle together, even in a gentle breeze, but the larvae are very common in quiet, protected sites in the South American jungle where they are apparently fully competitive with spiders.



William G. Eberhard

*Spiders are not alone in using webs to capture prey. Here a fungus gnat larva produces a sticky line for its web; each line is tipped with an adhesive ball. When prey gets stuck, it is reeled in and eaten.*

William G. Eberhard



*A mob of flies rests on the nonsticky web of a comb-footed spider. Whenever the spider comes near, the flies take to the air, hover until the spider retreats, then return to their resting spots.*

These descriptions of how their intended prey turn the tables on them make the spiders seem almost inept. But spiders are a large, successful group, and as might be expected, they have evolved a few tricks of their own for the insects. Since I am a spider enthusiast, I cannot end this article without mentioning some of these.

One of the strangest came to light only recently. It involves the trapeze flies and an elongate spider that can perform the feat of curling and uncurling its abdomen like a spring. In the jungles of eastern Colombia these spiders build strange webs consisting of only a few long, nonsticky lines strung between leaves and twigs without any apparent organization. Such a web would seem to be useless for entangling insects; nevertheless it does help the spider capture its prey. It functions, not as a trap, but as a landing site for trapeze flies. When a fly alights on a line, the spider begins to move slowly and stealthily toward it, taking up to five minutes to move only three inches. When it finally nears the unsuspecting fly, the spider gently waves its front legs, like a blind person tapping with a cane. One touch is enough to reveal the prey's location; the spider slowly turns 180°, pulls out a sticky line with its hind legs, and with the only quick movement of the entire attack, suddenly loops the line over its victim.

Moths are also common spider prey, but they are difficult for web spiders to catch. This is because moths are covered with detachable scales, and when they hit a sticky web, some of the scales stick to the web while the moth falls free. Two kinds of spiders, one in New Guinea and the other in the Americas, have independently developed similar, bizarre webs that are probably adaptations to overcome this defense of the moths. In both cases the webs are extremely elongate and perfectly vertical and have thus been christened "ladder webs." A moth striking the upper part of a ladder web has so far to fall that it is stripped of scales and firmly entangled before it can reach the bottom and free itself.

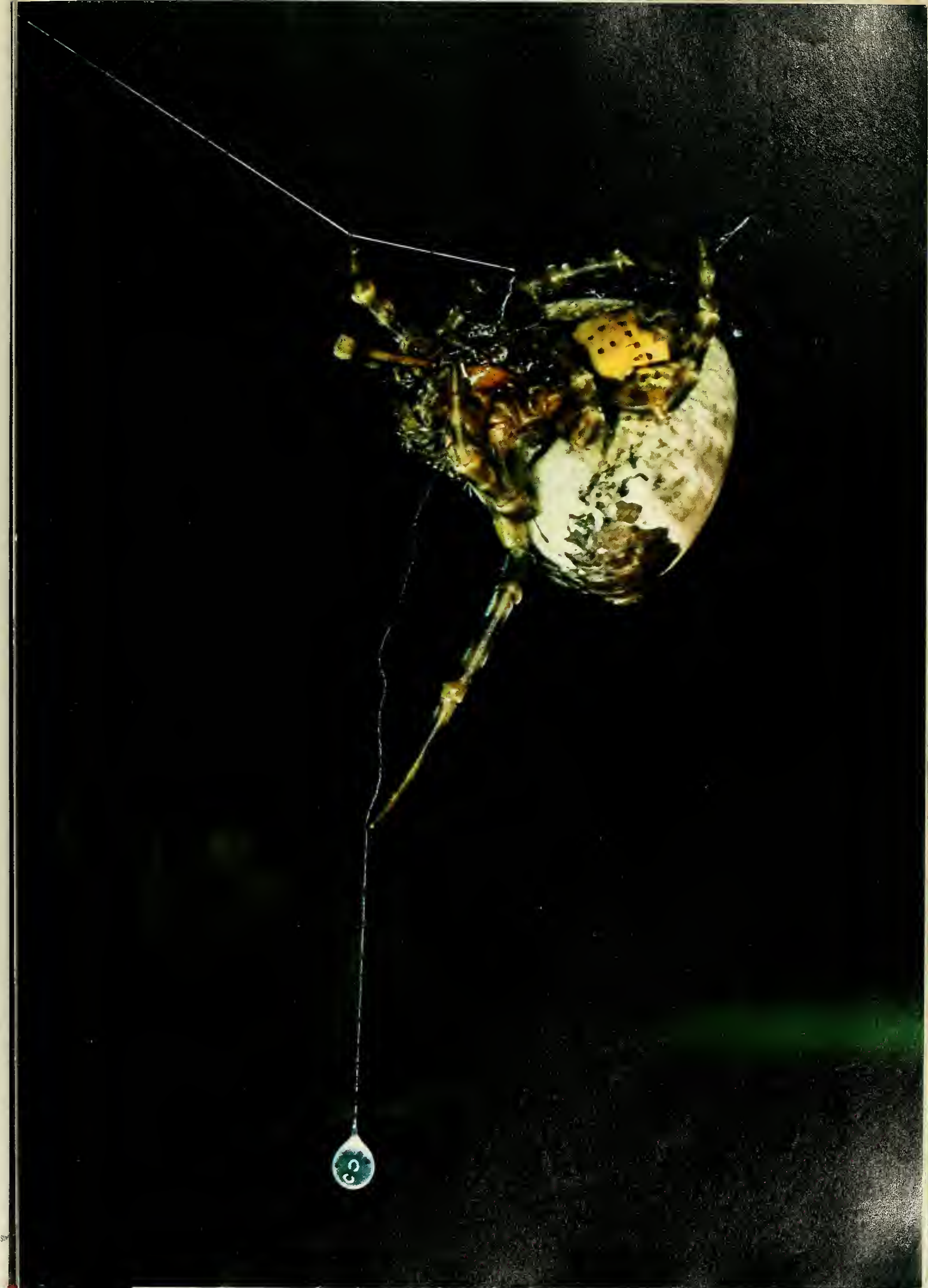
Another spider group has gone in for even more sophisticated moth-catching tactics. These species' webs have become reduced rather than extended, and consist of only a single short line from which a large sticky ball is suspended. These "bolas spiders" hold the line with one front leg and swing the ball at passing insects. This seems an incredibly ineffective way to go about catching prey, but recent observations have confirmed what naturalists had long suspected—that the spiders do not passively wait for prey to chance by but actively attract them by using a substance apparently similar to one produced by virgin female moths to attract their mates.

The spider begins by choosing an exposed site and making a ball; then, swaying slightly in the weak nighttime breeze, it settles down to wait, holding the line. The spider's tension is suggested by the nearly constant twitching of its front legs. Alertness is essential, since the spider's sense of vision is very poor. Probably it senses approaching prey by the hum of wings. This charged scene may last for many minutes before a fluttering white speck appears in the moonlight, swinging back and forth in the air downwind of the spider. The moth approaches erratically, seemingly unable to keep its flight pattern steady in the gentle breeze. But after coming to within about three feet, it appears to sense that something is wrong and speeds away. More waiting by the spider follows, until another erratic approach begins. The moth hovers closer and closer, and the spider, finally alerted to its presence, cocks its leg back ready to swing. It starts several swings, but holds up as the moth swerves first closer, then farther away. Finally the moth slips off to the side and disappears, only to reappear moments later downwind and begin another approach. Again it comes close, and again the spider cocks its leg. Suddenly, too fast for the human eye to see, the spider swings, and the moth flutters helplessly at the end of the line. The spider descends, embraces its victim while administering a paralyzing bite, then slowly wraps it securely in silk.

These glimpses of spider–insect interactions are by no means the end of the story. Insects of several other orders are involved in complex relationships with spiders in their webs, and wherever one looks in depth at spiders and their potential prey, all is complexity. Nature has been much more creative than our simple stereotypes have led us to believe. This is especially true in the tropics where the diversity of organisms and the opportunity for specialization are great. For naturalists, the beauty of these seemingly endless variations on basic patterns is both a source of pleasure and an inspiration to further study. ☐

*Hanging from a support line, a bolas spider of the genus* Mastophora *dangles the weapon for which it is named. The sticky ball at the end of the line is swung at passing insects such as moths.*

Mark Stowe



# A Fish with Double Vision

*Native to the Galápagos Islands, this animal has a most unusual optical system*

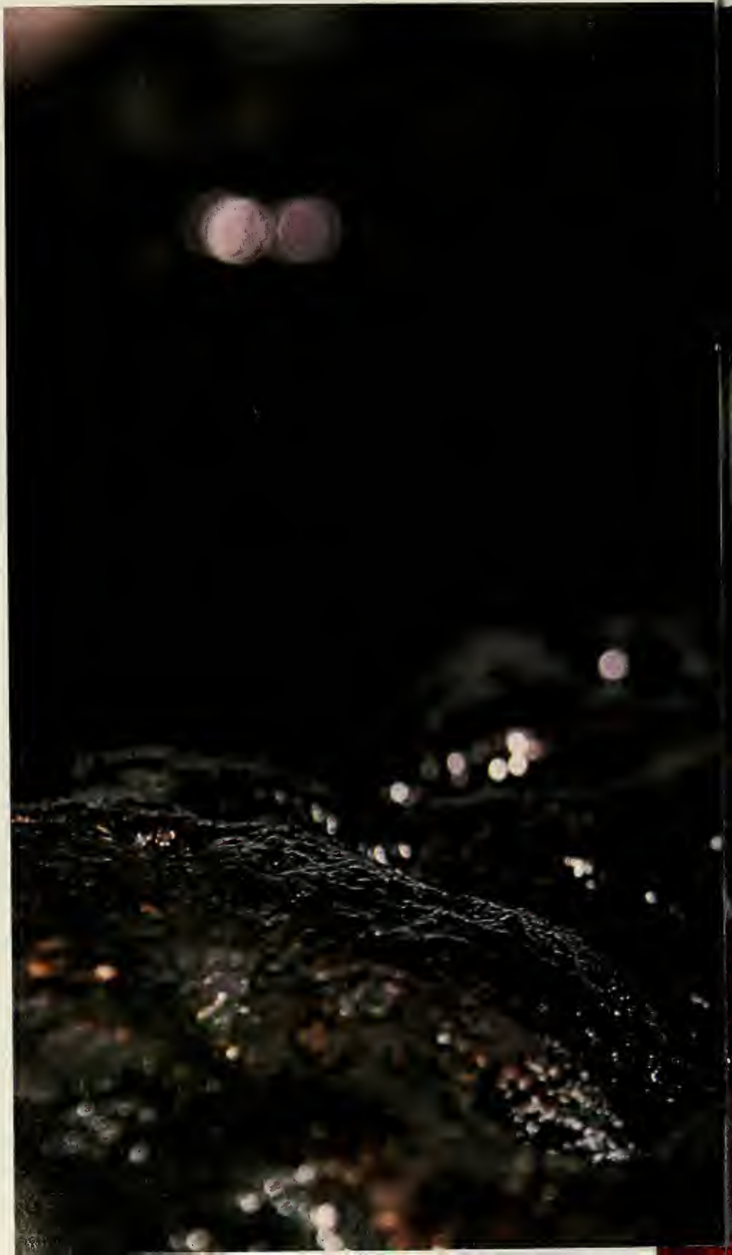
**Text and photographs by John K. Stevens and Katharine E. Parsons**

The Galápagos Islands, which lie about 650 miles off the coast of Ecuador, are probably best known as a place where Darwin made observations that helped him develop his theory of evolution. They are also famous for their gigantic land tortoises and unusual birds. In addition to these and many lesser-known animals, the islands have a small amphibious fish found nowhere else—*Dialommus fuscus*. This fish is probably unique in that its eyes have two absolutely flat corneal windows that form a prism and enable it to see sharply in both air and water.

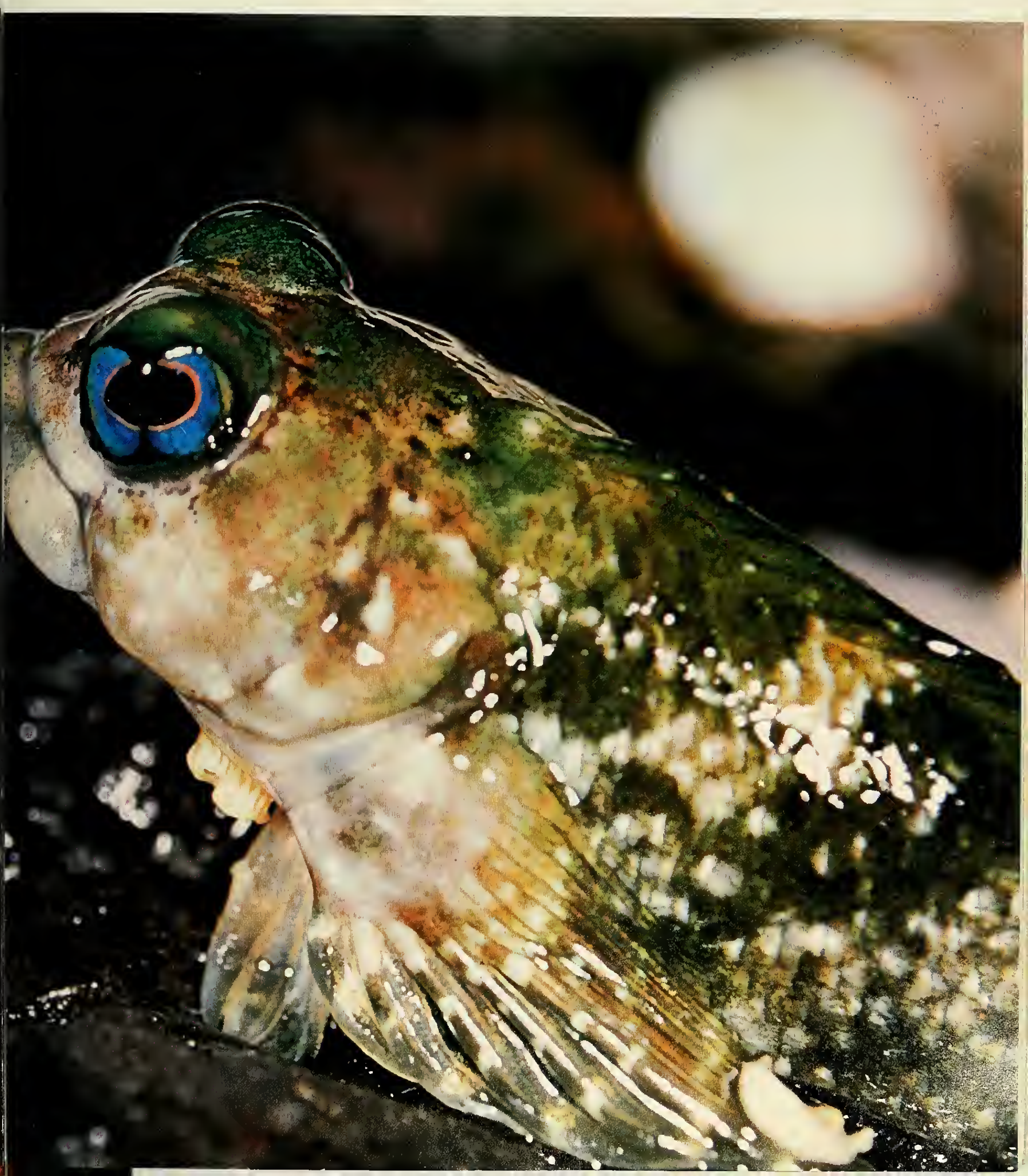
In order to study the fish and its optical system, we made a scientific trip in 1976 to Santa Cruz, the second largest of the Galápagos Islands, and set up a laboratory in the Charles Darwin Biological Station.

*D. fuscus* is approximately two to six inches long. Its location and activity determine its body color, which ranges from gold to black. Its eyes have a brilliant iris of blue, black, and red, and the two corneal faces of each eye are set at an angle of 110 degrees to each other. We found the fish most often in the tide pools along the rocky shores of this volcanic island. Since it lacks a swim bladder, the fish maintains its position in the water with its tail and fins, which it also uses to pull itself out of the water. In fact, *D. fuscus* spends up to 50 percent of its time out of the water, coiled up on the lava rocks waiting to jump either at food or back into the tide pools to escape its predators. It moves quickly and is difficult to catch, which may be one reason it has not been widely studied in the past.

*D. fuscus* is an aggressive and voracious feeder. In the laboratory, it would hop on a rock and literally tear food from our fingers. In the field, however, it curls into the small crevices of the lava rock and feeds opportunistically off the tiny shrimp and other crustaceans that the surf carries in. Despite its small size, it can often be located by the pecking noises it makes as it snaps at its prey against the



*This specimen of* Dialommus fuscus *has just climbed out of the water. In a few minutes its body will turn black, matching the lava rock on which it is sitting. Its blue, prismatic eyes, with their clear vertical division, will also turn black on exposure to the bright light.*

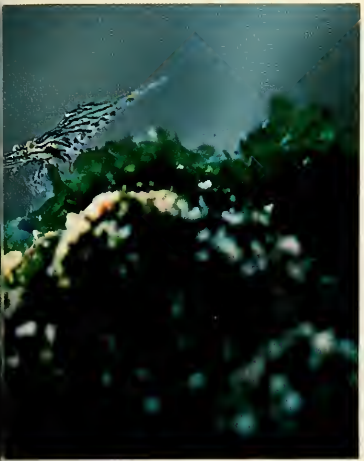


*The prismatic effect seems to have disappeared from the eyes of this fish, which has just jumped underwater. Its eyes will soon change color, adapting to the diminished light.*

rock. With its extremely mobile head and body it would often "fish" for food stranded in tiny pools of water only fractions of an inch in diameter. To the casual observer, the fish appears to be eating the rock itself. Because of this characteristic feeding behavior, the native name for *Dialommus* is *chupa piedra*, "rock eater."

To leave a tide pool, the fish first "hyperventilates," that is, takes several deep breaths at the water's edge, curls its tail around, and then propels itself out of the water like a rocket. The pelvic and pectoral fins work together with the tail to move the fish's body rapidly over the rocks. It leaps into the air to escape terrestrial predators, such as lava herons and carnivorous crabs, or surfs across a tidal pool to another rock. We often observed *D. fuscus* out of the water for twenty minutes or more, and during these terrestrial sojourns it kept its gills clamped shut, much as we keep our mouths closed when holding our breath underwater.

During the course of our investigation we heard from a nature guide that *D. fuscus* might inhabit other islands besides Santa Cruz, so we persuaded three fishermen (others refused because of the pervading rough seas) to



*Tiny shrimp, sometimes of microscopic length, wash up in tide pools along the coast and become food for* Dialommus fuscus.

*The habit of pecking at these shrimp and other crustaceans on the rocks has caused the native population to dub the fish the rock eater.*

take us to Hood Island and Floreana Island. On Hood, we found the fish in only one location, on the island's south side by a blowhole (a hole in the rocky roof of a sea cave through which incoming waves force upward a powerful jet of water). We were astonished to find the fish in small pools on ledges well above the tide line—pools they could only have reached by being propelled up through the blowhole under several hundred pounds of water pressure.

On Floreana, which has sandy beaches and where there is less surf action than on Hood, we found only a few of the fish in one of the bays. Our three skilled fishermen were able to catch the fish with their hats and their bare hands while we struggled with nets. For some strange reason, *Dialommus* did not seem as amphibious or as hardy on Floreana (two died after an hour in our collection bucket) as the fish we studied on the rockier islands of Hood and Santa Cruz.

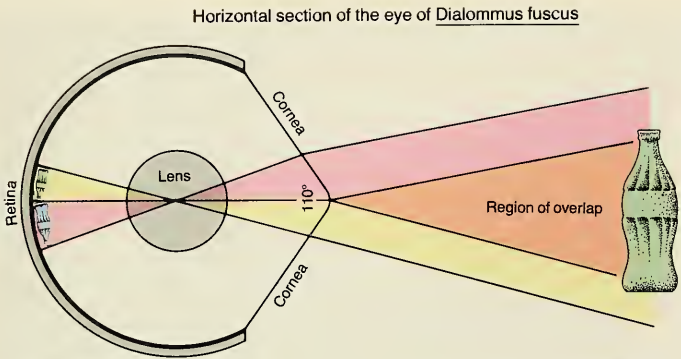
Its chameleonlike characteristics enable *D. fuscus* to blend into the background, whether under or above water. On Hood Island, for example, when in the water, the fish were a deep golden color, like the algae peculiar to the tide pools there; those on Santa Cruz, by contrast, were green, brown, and tan, blending with the tide pools on that island. When the fish left the water, however, they changed color within a matter of minutes, turning black to match the lava rocks. We do not know what mechanism accounts for these color changes. They may be triggered by exposure to light or to changing levels of oxygen or carbon dioxide in the fish's blood.

Despite these intriguing characteristics, we focused our scientific investigation on trying to understand and reconstruct the optical system of *D. fuscus*. First, in the laboratory, we examined an eye in vivo with a conventional ophthalmoscope, which made direct viewing of the retina possible. We then withdrew minute samples of fluid from the anterior and posterior chambers of the eye, and measured the refractive indices of the aqueous and the vitreous humors—the fluid and the jellylike substances, respectively, in the chambers.

To measure the focal length of the fish's eye, we used a helium-neon laser. First, the lens was removed from the eye and placed in a solution with a known index of refraction. The laser was then shined through both the solution and the lens, which focused the laser's parallel rays to a single point. The distance from the center of the lens to this point was recorded photographically and, as expected, corresponded to the focal length of the lens.

Finally, we quick-froze a series of whole eyes with freon and cut them into 40-micron-thick serial sections. Photographs of these serial sections were used later to reconstruct the entire eye on a computer. When all of this information was put together, it became possible to model the optical system of the entire eye of *Dialommus*.

During our study, we found that the refractive index of the fluids in the fish's eye approximated that of sea water. Consequently, it was clear—as others had suggested before—that *D. fuscus* had evolved an equivalent of a



Joe Le Monnier

*The combination of the fish's prismatic cornea and the index of refraction of 1.0 in the air leads to a double image of the world when out of the water. This double view, or "binocular" of 20° to 30° overlap, may contribute to depth perception or may simply be an evolutionary aberration.*

*The chameleonlike ability to blend with its surroundings makes the fish almost unrecognizable, above, and barely discernible, right.*

face mask that made it possible for the fish to see clearly both in the air and underwater. Just as we need an air space in front of our eyes to see underwater, so this fish needs a "mask" of "sea water" to focus in the air.

Our model, however, predicted one interesting difference between a face mask and this fish's eye. Since the eye's corneal windows consist of two flat faces similar to a glass prism, set at an angle of 110 degrees, and since the fluids inside the eye match the refractive index of water, the eye should produce a normal image underwater. But our analysis shows that when the fish comes above water to feed and looks directly at an object (through the center of the "prism"), there should be a 20- to a 30-degree field over which it sees double, perceiving every object twice with each eye. This double view may simply be an aberration—the evolutionary price *D. fuscus* has paid for its aerial vision. On the other hand, it may be a mechanism that makes depth perception possible. Since *D. fuscus* sees things twice above water, it can make use of visual disparity cues, which humans obtain from two eyes, with only one eye. If true, this possibility might represent a unique evolutionary development that should be explored in greater detail.

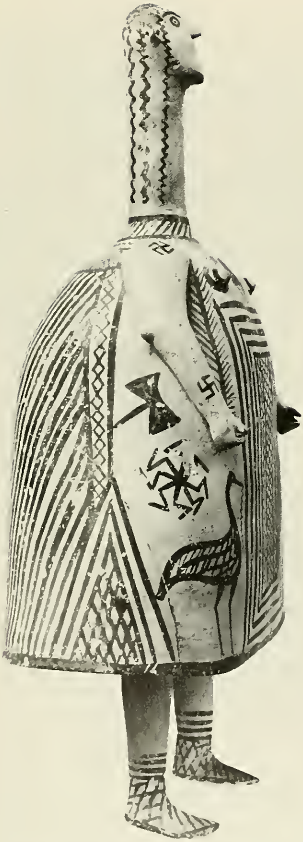
We later confirmed empirically with our photographs of the fish that a double image probably does occur when the fish is out of the water. Photographs of the fish's eye taken at a sharp angle showed the iris twice, demonstrating that the cornea is indeed a prism when above the water. Consistent with our model, however, no double iris showed up in any of our underwater photographs.

We were most surprised to discover that *Dialommus* had also evolved, in the anterior chamber of its eye, a photopigment that changes in optical density on exposure to bright light. Normally the iris is a brilliant blue, but when the fish is exposed to bright sunlight, the iris and the fluid in the anterior chamber of its eye turn black like the rest of its body. Since the fish lacks a constricting iris like that in humans, this change presumably protects the fish's retina from the brilliant equatorial sun. Thus, it appears that *D. fuscus* not only has special vision but may also have anticipated by several million years the "variable density sunglasses" now available to humans. ☐

# Origin of the Swastika

*Ceremonies in India have shed new light on an ancient symbol*

**by Stanley A. Freed and Ruth S. Freed**



*Many theories of the origin of the swastika are based on its association with other symbols of recognized meaning, such as this clay female figure from a seventh-century B.C. Boeotian grave.*

M. Chuzeville, Musée du Louvre

The swastika is humanity's oldest, most widespread symbol of any complexity. The name is derived from a Sanskrit word that means "object of well-being." Originating some 6,000 years ago in the Middle East, the symbol had spread over Europe and parts of Asia by the early centuries of the Christian Era. In recent times, the Third Reich, exploiting the symbol's mysterious magical power, impressed the swastika into the consciousness of the world. Hitler's early biographer, Konrad Heiden, described the impact of its first public display in prewar Germany: "In 1921, Hitler's new red banner with a black swastika in a white disk was unfurled in the open for the first time. The effect was so inflammatory that Hitler himself was surprised and pleased. [It] gave Hitler one of his mightiest magical weapons. . . . An uncanny power emanated from the mysterious sign."

Because of the association of the swastika with Nazism, the nations most affected by the Second World War regard it as a symbol of barbarity. But apart from this recent, menacing aspect, which covers only one percent of its history, the swastika is a powerful sign of good luck. This quality, its magical aura, and its symbolism have roots in the most ancient civilizations of Mesopotamia and Iran. In India, where it is widely used in Hindu ceremonial and as a decorative motif, the swastika combines astronomical and religious symbolism. This combination provides our best clue to its original meaning, for a continuous religious tradition can be traced from modern Hinduism to the religion of the Harappan civilization of the Indus Valley, which has been dated to the third millennium B.C.

The trail begins with the earliest recorded occurrences of the swastika at Samarra in central Mesopotamia and at Susa in western Iran, where clear swastikas appear on pottery from about 4000 B.C. About 3000 B.C., the swastika was depicted on pottery from Troy in northwestern Asia Minor and, somewhat later, on seals from the Harappan civilization. By the beginning of the Christian Era, the swastika was well established in an area from India through western Asia into Europe. This zone of primary diffusion largely coincides with the area settled by speakers of Indo-European languages. Although widespread in the Middle East and Asia Minor, it was notably absent in nearby Egypt, except on imported goods such as Greek pottery, and was generally unknown in the rest of Africa.

A later diffusion of the swastika took place in central and eastern Asia. Buddhism adopted the swastika from Hinduism, and as Buddhism spread from India into Tibet, China, and Japan, the swastika traveled with it, retaining its symbolic meaning of good luck.

*A swastika decorates this Hindu temple in New Delhi. Perhaps the best clues to the swastika's original meaning lie in India, where it has been used in daily and ceremonial life since antiquity.*

Rajesh B

*The true, hooked-cross swastika was generally absent from the New World before its introduction by Europeans. At right is an exception, one of several copper swastikas unearthed from one of the 2,000-year-old Hopewell mounds in Ohio. Because of its isolated occurrence, this find may be interpreted as a case of independent invention of a shape whose symbolism, if any, would have been unrelated to the swastika of the Old World.*

Field Museum of Natural History, Chicago

The most vexing distributional problem regarding the swastika is the question of its occurrence in the New World in pre-Columbian times. Almost all of the pre-Columbian designs alleged to be swastikas, such as the cross in a circle, which is common on shell ornaments, and the spirals that often decorate pottery, bear only a modest resemblance to the typical hooked-cross swastika of the Old World. The elimination of such dubious examples all but removes the swastika from the pre-Columbian New World except for one case, the 2,000-year-old Hopewell mounds in Ohio. There, in the early 1890s, archeologists unearthed a cache of copper objects that still constitutes one of the most remarkable finds in North America. Included were several true swastikas, whose existence is puzzling, for there are no comparable objects from other sites in adjacent regions. Ordinarily, artistic motifs diffuse rather widely—for example, the cross in a circle occurs in both the Old and New Worlds. In post-Columbian times, Europeans brought the swastika to the New World, and American Indians have occasionally used it as a design element.

Scholars have proposed a considerable number of theories for the symbolic meaning of the swastika: that it represents the sun, moon, the yearly rotation of Ursa Major, cardinal points, eternity, Zeus, Baal, fire, several Hindu deities (among them Agni, Indra, Vishnu, and Ganesh), light, forked lightning, water, the union of the sexes, fertility, and a fire-making apparatus known as the fire drill. Ranging from reasonable to far-fetched, these theories rely on the proximity of the swastika in various contexts to symbols of recognized meaning or on the reputed natural functioning of the human mind. John, Prince Loewenstein, for example, in an article published in 1941, wrote: "The *swastika*, which from the earliest times was so closely associated with woman, must . . . have been a fecundity symbol." He cites such evidence as the presence of the swastika on female face urns from Troy dating to about 3000 B.C. and on objects associated with women, such as spindle whorls and loom weights.

A common proposition is that the swastika represents the sun. In 1894, Count Goblet d'Alviella, following several other authors, argued the theory largely on the basis of the association of the swastika and symbols, images, and deities of the sun. The frontispiece of his book *The Migration of Symbols* shows Apollo, clearly represented as a sun god, with a swastika on his breast.

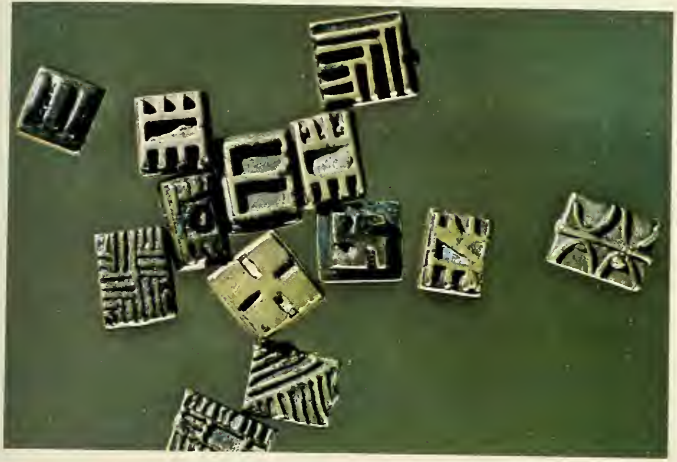
Anthropologist Zelia Nuttall advanced a theory based chiefly on "ideas which would naturally suggest themselves to the mind of the primitive observer." Such a person, observing the yearly rotation of Ursa Major around the pole star and concentrating upon its image at four equidistant positions, would perceive the form of a swastika. Her own experience illustrates the mental processes involved:

> In a flash of mental vision I perceived a quadrupled image of the entire constellation, standing out in scintillating brilliancy from the intense darkness of the wintry sky . . . it bore the semblance of a symmetrical swastika of giant proportions. . . . I left my window, on that memorable night, with a growing perception of the deep and powerful influence the prolonged observation of Polaris and the circumpolar constellations would naturally have exerted upon the mind of primitive man.

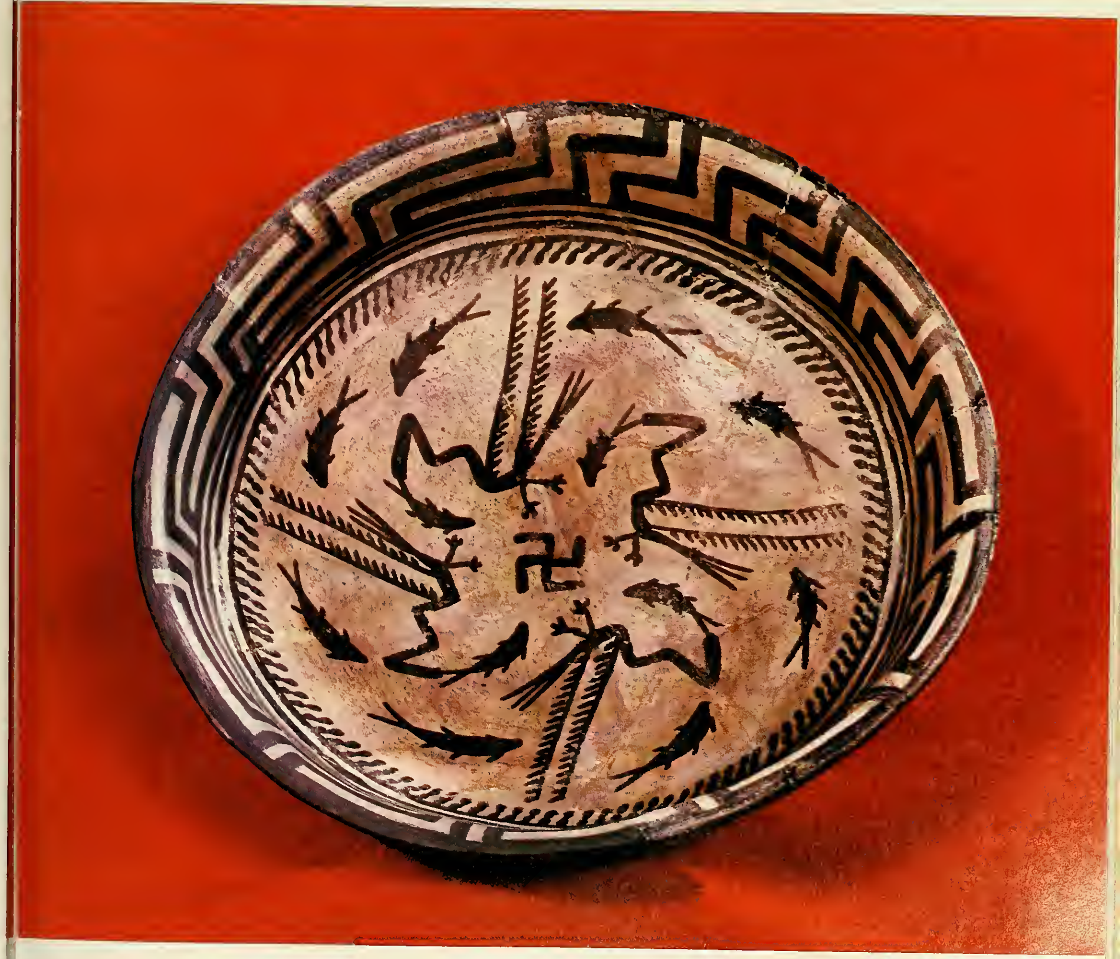
Such interpretations are unconvincing principally because of the lack of a clear connection between the form of the swastika and its alleged symbolic meaning. The circular sun is not readily apparent in the angular swastika; the connection between the swastika and, for example, an elephant-headed deity (Ganesh) or the union of the sexes is even more obscure. Moreover, the insight that comes from observing how people actively use a symbol is lost when interpretations are based solely on archeological artifacts that represent dead cultures. The best context in which to search for the symbolic meaning of the swastika is in a living society where the symbol has from ancient times been a routine feature of ceremonial and daily life. India provides such a setting.

Swastikas are in constant use in the north Indian village where we have lived for extended periods. They are prominent in ritual life, especially in ceremonies that mark a beginning, such as births and marriages. A priest officiating at such rituals sometimes includes a swastika in the symbolic design, drawn in colored powders on the ground, that serves as an altar for the fire rite. In ceremonies of birth, marriage, and at festivals, women often draw swastikas on pots, the ground, and walls. When a symbol representing a festival is removed after the conclusion of the festival, women

Rudi Haas

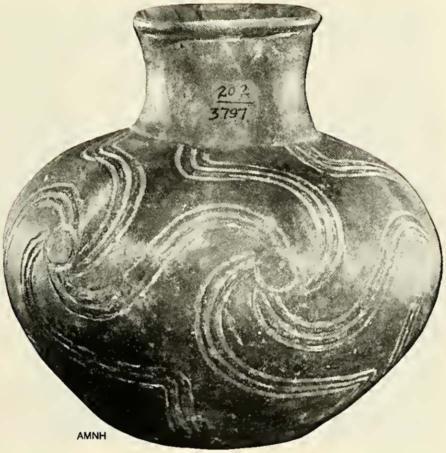


*Left: The swastika appears on one of these Ashanti gold weights from Ghana, used to weigh gold. Although it probably represents a relatively recent diffusion of the Old World symbol, the West African swastika could have evolved independently as a result of experimentation with geometric patterns.*
*Below: One of the earliest known swastikas is painted on a Samarran pottery bowl dating to about 4000 B.C.*



Staatliche Museen zu Berlin

豚八
とんかつ 豚八



AMNH

*If the design on this Mississippian Indian pot had any meaning, it was probably unconnected with the symbolism of the Old World swastika. Nevertheless, some archeologists consider such designs to be variants of the swastika.*

sometimes draw a swastika in its place so that no evil may enter the empty space. We observed the swastikas in such rituals but did not always pay particular attention to them, since they were ubiquitous. The villagers told us that they drew swastikas because they were auspicious, and we could not elicit more specific information.

One day we were watching a ceremony known as *barat lena* (reception of the wedding party), one of the series of rituals that constitutes a wedding. At *barat lena*, the groom is welcomed by men of the bride's family. Since we had often seen similar rituals, we expected to see nothing particularly new, but this time we had a stroke of luck. A large brass tray containing sacred paraphernalia and symbols had been prepared for the ceremony; on it was a faint swastika drawn in turmeric. At each of the nine points that, when connected, defined its form (the center, vertices of the angles, and the end points of the arms), a pile of rice had been placed.

We were forced to see with fresh eyes what we had looked at many times before. Like most people who have written about the swastika, we had been in the habit of looking at its arms. The prominent rice piles and faint arms directed our attention to the nine points arranged in a three-by-three square as the essential feature of the swastika, a shift of focus that led us to a new interpretation of its symbolic meaning.

*Throughout much of the world today, the swastika retains its value as a symbol of good luck. It was spread into Tibet, China, and Japan, left, in association with Buddhism, which adopted the symbol from Hinduism.*

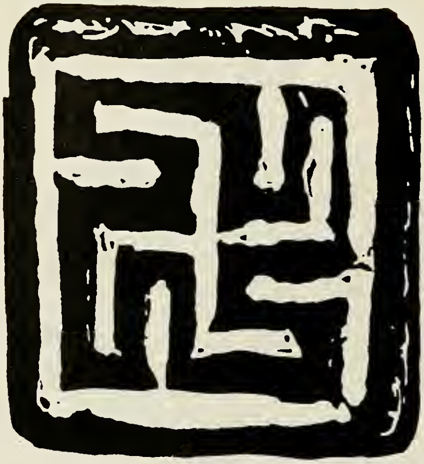
e Bartruff

In Hinduism, there are nine supernatural beings known as the *graha*. They are the five planets visible to the naked eye (Mercury, Venus, Mars, Jupiter, and Saturn), the sun, and the moon—all seven considered to be gods—and the ascending and descending nodes of the moon, conceived of as demons that pursue the sun and moon and cause eclipses. (The nodes are the points on its orbit when the moon lies in the same plane as the sun and the earth, the only times that eclipses can take place.) Traditional Hindu astronomy designates the *graha* as planets; the gods and demons immanent in the *graha* are called the planetary deities.

In Hindu samskaras (orthodox ceremonies), the *graha* are usually represented by nine squares in a three-by-three pattern, each one often bearing the symbol of a specific deity, or more simply by nine dots. The central square represents the sun, the creating principle, around which are arranged the other planetary deities that, together with the sun, represent the entire universe. Further indications that drawings of the *graha* are intended to encompass creation and the universe are the one or more short, projecting lines that are often drawn at the edge of the three-by-three pattern of squares. Such lines stand for the multitude of deities not specifically represented in the drawing of the *graha*.

In the context of a Hindu wedding ceremony, where the nine planetary gods are so prominent, the connection between the swastika and the planetary deities becomes obvious. The symbolism of the swastika is contained in its nine points, which represent the planetary deities; the lines are a dramatic way of connecting the points to make them more visible. The swastika can be drawn more quickly than a three-by-three square, and there is a feeling of motion and excitement about it. The swastika may have been used as a substitute for squares or other representations of the planetary gods so long ago that its original meaning has been forgotten. On one level, the swastika represents the planetary deities; at a deeper, or more general, level, it symbolizes the power of creation and the universe, just as does the three-by-three pattern of squares that also represents the *graha*.

The connection of the swastika and the planetary gods is often seen in designs drawn to serve as altars for fire ceremonies. We photographed one altar displaying both a large swastika and a small drawing of the nine squares. This double appeal to the *graha* was justified in this case, for the ceremony was intended to protect a male infant and his family from the harmful effects of a malevolent astrological sign. The baby had been born under the sign of the Mula Nakshatra. There are twenty-seven nakshatras, or lunar mansions, conspicuous stars or groups of stars that lie near the moon's path as it revolves around the earth. Recognized and named in ancient times, they are believed to affect the



*The swastika appears on seals from the Harappan civilization of the Indus Valley, which dates from about 2300 to 1700 B.C. Hinduism is a living religion with roots in this ancient culture.*

fate of individuals for better or for worse. Rural north Indians believe that the Mula Nakshatra has the most dangerous influence. A male child born under that sign either dies or, if he lives, brings ruin to his family.

Invoking the powerful planetary gods as protection from a malign nakshatra was doubly appropriate because of a connection between the *graha* and the nakshatras. In Hindu mythology, the lunar mansions were the daughters of Daksha (Ritual-Skill), who gave them to the moon as wives. The first offspring of this union were four of the *graha*: Mercury, Venus, Mars, and Jupiter. The four small circles in the angles of the intersecting arms of the swastika drawn for the Mula Nakshatra ceremony may represent these four planets born from the union of the moon and four nakshatras; this added symbolic element would be appropriate in a ceremony for a nakshatra.

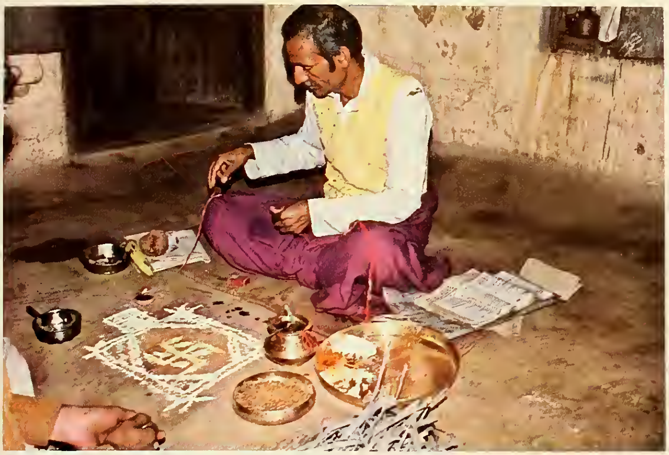
To use the identification of the swastika with the *graha* based upon ceremonies observed in 1978 as grounds for a theory of the origins of the symbol assumes some continuity of Indian religious tradition from ancient times to the present. Such an assumption is by no means unjustified. Links between the Harappan civilization of the Indus Valley, which dates from the third millennium B.C., and modern Hinduism appear well established. Stuart Piggott, in *Prehistoric India*, concluded that Harappan religion was "essentially Indian from the start." The swastika appears on Harappan seals, as does the grid, another symbol that depicts nine points and may also have represented the planetary deities.

The relationship of the swastika and the planetary gods fits the history and distribution of the symbol rather well. The necessary astronomical knowledge existed at the swastika's apparent place of origin. The Mesopotamians had identified the five planets, and they had also learned to "half predict eclipses," as American anthropologist Alfred Kroeber phrased it. Thus, they would have known about the ascending and descending nodes of the moon. Moreover, the Mesopotamians identified the planets with gods.

When the week was invented in western Asia, the names of the Babylonian planetary deities were used to designate the days. As the week diffused over the Old World, the peoples who accepted it, such as the Greeks, Romans, Germans, and Indians, renamed the days after their own deities. The connection of heavenly body–god–weekday from India to Europe coincides with the area most anciently identified with the swastika, strengthening its interpretation as a symbol of the planetary gods. Its comparative absence in other areas of the world also is in accord with this interpretation. In Egypt, for example, where the only planetary deity was the sun god, the original symbolism of the swastika would have had little meaning. The swastika was probably spread as much by the migration of the Indo-European tribes as by diffusion; in any case, it is more closely identified with speakers of Indo-European languages than with other populations and has found its greatest use among them.

Consideration of the swastika as a symbol of the planetary deities would simplify some matters that have occupied archeologists and historians. The problem of alternative forms of the swastika could be reappraised. Symbols that lack nine clearly defined points in a three-by-three pattern are probably in most cases not swastikas. A reanalysis of such forms would bear on the problem of the diffusion of the swastika, especially its presence in the New World. The various spirals and crosses in circles that pass for swastikas in the New World probably had nothing to do with the hooked cross of the Old World. The copper swastikas from the Hopewell find, however, remain mysterious. Whether the Hopewell swastikas are evidence of Old World influence or were independently invented in the New World, it is hard to explain why the design was not further diffused.

In recent times, there appear to have been two peak periods of scholarly interest in the swastika: the first about the beginning of the twentieth century; the second during the period of the Third Reich in Germany. At present, analysis of symbols is one of the noteworthy interests in anthropology. Yet one of the most famous—or infamous—symbols of all has been largely ignored. Because of the many archeological investigations in the Old and New Worlds since the Second World War, this would seem to be a good time to advance our understanding of this mysterious symbol, which recalls the deities and demons that guided human destiny at the dawn of civilization. Its principal heirs, the Indo-European speakers, still respond to its mystical power. □



Stanley A. Freed

*In specific instances, the details of Hindu ceremonial suggest that the swastika symbolizes ancient planetary gods. Left: A swastika is central to a design that will serve as the altar for a fire ceremony. On one edge of the surrounding square is a grid that represents the* graha, *nine planetary gods. Below: In a wedding ritual, a faint swastika, drawn in turmeric, is marked by nine piles of rice. This arrangement emphasizes the nine points contained within the swastika's form.*

# Indian Fires of Spring

*Hunters and gatherers of the Canadian boreal forest shaped their habitat with fire*

**by Henry T. Lewis**

Following years of research—and sometimes acrimonious argument—environmental agencies across North America have begun implementing programs of prescribed burning. They are setting low-intensity, controlled fires to change or maintain natural environments. In addition, many fires started by lightning are now allowed to burn in high-altitude wilderness areas where there are few human habitations or timber resources. Such forestry management burning is not new. It has been carried out on a small scale for several decades within certain restricted habitat types, such as the longleaf pine forests of southwestern Georgia. But the widespread change in official attitude marks one of the more significant developments of this century in the forestry and range management sciences.

We are just beginning to appreciate the complexities and sophistication of this age-old custom. Anthropologists have noted habitat burning by nearly all known populations of North American Indians. Similar reports from Latin America, Africa, Eurasia, and Australia indicate the near universality of these practices among other hunters and gatherers, as well as among pastoralists. Unfortunately, the opportunities for direct observation have all but disappeared, except for isolated portions of Africa, Southeast Asia, and Australia where burning takes place surreptitiously or in the face of ineffective law enforcement.

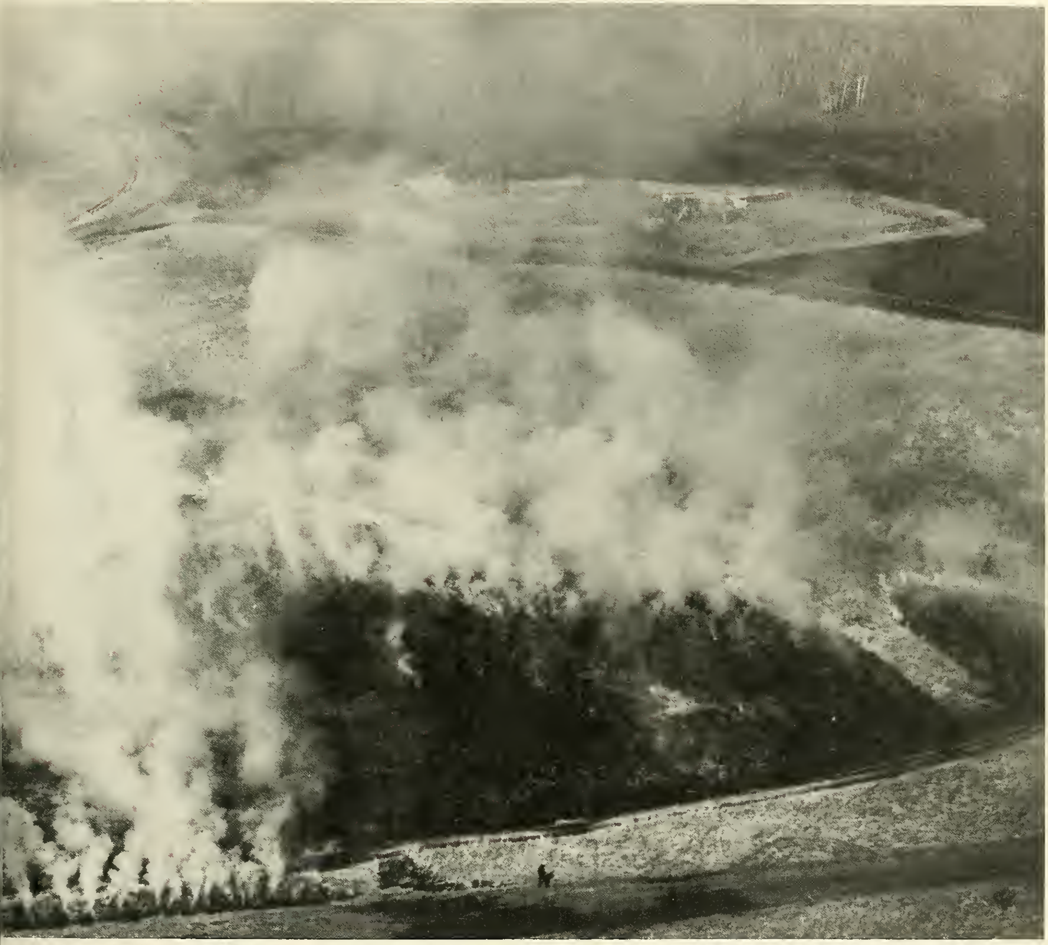
The Indians of Canada's northern boreal forests, or taiga, are among those who until recently employed fire to control and alter selected habitats. In Alberta's remote northern section, Slavey, Beaver, Cree, Chipewyan, and Métis (so-called half-breeds) maintained the traditional practices until the completion of the Mackenzie Highway in 1949, when oil field developments brought an end to the region's isolation. With the intrusion of roads and communication systems, environmental agencies were finally able to enforce existing fire laws. Today, just when provincial and national agencies are discovering the advantages of controlled burning, only the oldest Indians, those over sixty, can recount their own folk science of fire. (Members of the younger generation may remember occasional, secretive firing of isolated meadows, but they are usually poor or unwilling informants because they have been much influenced by public attitudes about fire.) A Beaver Indian woman reminisces:

> Why the bush is so thick is because they stop burning; the Indians stopped burning. From about five miles from here you could see straight prairie right to Childs Lake and that timber. Did you ever see them prairies? My goodness, I even remember. It was really prairie, just prairie, you know; here and there you see little specks of woods, and if there were trees there, they were quite huge.

In northernmost Alberta, the largest grassland areas are the intermittent prairies of the lower Peace River basin, which range in size from thirty to more than one hundred square miles. Meadows of but a few to several hundred acres are scattered widely, and deep within the boreal forest, there are small clearings, or swales, in areas that remain waterlogged throughout spring, summer, and fall. The countryside is also broken by meandering strands of grassland associated with streams and more swampy water drainages. These boreal forest sloughs, all but impassable in the summer, are the favored habitat of beavers, moose, muskrats, snowshoe hares, voles, and mice.

To Canada's wheat growers, this region constitutes a last frontier where forestlands are still being cleared for highly mechanized cultivation. The original pioneer farmers, however, were not faced with vast, uninterrupted stands of forest. Those early settlers who arrived in the first quarter of this century with their hand tools and horse-drawn plows found extensive prairies and parklands that supported

Henry T Lewis



*John D'or Prairie, a grassland created by the Indians' traditional use of controlled burning, is still maintained by annual spring fires authorized by the Alberta Forest Service.*

untold numbers of woodland bison, the remnant populations of which are today found only in Wood Buffalo National Park. ("My father told me that long time back there were plenty of buffalo here, all the way to Cold Lake. We were Plains Cree, not like those bush people up north. Now it's all bush here too," complains a Cree Indian from Frog Lake in central Alberta.)

George M. Dawson, a naturalist and government surveyor, wrote in 1879:

> The origin of the prairies of the Peace River is sufficiently obvious. There can be no doubt that they have been produced and are maintained by fires. The country is naturally a wooded one, and where fires have not run for a few years, young trees begin rapidly to spring up. The fires are, of course, ultimately attributable to human agency, and it is probable that before the country was inhabited by the Indians it was everywhere densely forest-clad.

The High Level–Fort Vermilion prairie, an area of roughly one hundred square miles, was regularly burned each year. Smaller prairie-meadows, such as Tall Cree, John D'or Prairie, and those at Hay Lake and Bistcho Lake, were also fired, as were myriad small meadows, swales, and sloughs. Within the whole of northwestern Alberta, a region of some 26,000 square miles, an estimated 650 square miles was burned in any given year. Ironically, these fire-maintained prairies provided a measure of preadaptation for the pioneer farming that displaced Indians from some of their prime hunting lands.

Along with less dynamic conditions (climate, soil, exposure, topography, permafrost, availability of seed plants), fire serves to counteract the tendency toward forest uniformity. A mix of variably aged forest, brush, and grassland types provides for a greater number as well as a diversity of plants and animals. In setting fires according to an intended pattern, hunter-gatherers can reap these benefits and, at the same time, reduce the risks of natural

Henry T. Lewis

*A meadow has become lush three weeks following a spring fire, while unburned dead grass (foreground) inhibits new growth. With annual burning, the grassland area expands as trees on the periphery are affected.*

fires, whose frequency, intensity, extent, and effects are unpredictable.

In northern Alberta, Indian fires were characteristically set during the first week of spring. Such spring burning can maintain herbaceous plants at high levels of productivity year after year in selected sites, without disruptive effects. This is favorable for bison and other game animals, especially species that frequent the border areas separating forest, grassland, and water. In the boreal forest regions of northern Canada, these species include moose, elk, deer, bears, snowshoe hares, beavers, muskrats, and further along the food chain, a variety of dependent predators. Even caribou, which depend mainly on the lichens and mosses of mature forest stands, will at times forage in clearings or along sloughs and riverbanks.

Spring burning promotes early growth, an important advantage to hunting and gathering in a region with only sixty to eighty frost-free days a year. With its surface cleared and blackened, the frozen soil of a meadow is heated by the sun, and growth occurs two to three weeks earlier, and is lusher, than in unburned areas. In northern latitudes, where the natural recycling of nutrients is slow, fires also help "unlock" nutrients, increasing their availability to plants.

The practice of spring burning thus aided the northern hunter-gatherers in meeting their subsistence goals. Other reasons for burning meadows, whether close to campsites and settlements or farther removed on traplines and hunting grounds, were to reduce fire hazards, facilitate travel, improve berry patches, provide firewood (from fire-scarred trees and brush at the edges of meadows), and decrease populations of black flies and mosquitoes. Aesthetic and religious feelings were bound up with these practical considerations. "Windfalls—where there's all dead trees—those aren't good places," says a Slavey Indian. "Nothing lives there, nothing is any good. We set fire to those places in the spring. That way the fire makes the forest live again."

In controlling fires, the Indians made the same fundamental evaluations employed in forestry and range management today. Foremost was the rule of seasonality: fires were set in spring, occasionally autumn, never summer.

The conditions under which grass fires may be set during the early weeks of spring persist for only a few weeks or, in some years, for but a few days. By mid-April, forest openings are cleared of snow and the exposed grasses dry much more rapidly than the trees, shrubs, and grasses in nearby forests. The dry meadows and prairies can be burned cleanly and evenly, while snow may still be scattered throughout the forest understory and along the shaded edges of meadows. The likelihood of fire spreading into the denser vegetation is affected by such factors as wind, fuel types, the depth and density of cover, temperature, north-south exposure, and slope; but the most significant deterrent to the spread of fire is the greater moisture content of the fuel in the shaded, thick bush or forest. Directly linked to this are cooler temperatures and a higher above-surface relative humidity. Relative humidity is the easiest and most frequently measured variable for indicating differences in burning potential: in the grasslands it ranges from 25 to 35 percent, while under canopies of brush and trees it is from 45 to 55 percent.

Also important for spring burning is that soils are still damp or even frozen, with the result that surface fires do not injure the subterranean portions of dormant plants. Later on—at the peak of summer growth, for example—an intense grass fire will not only consume above-surface portions of plants but can also adversely affect tillering or damage root systems. Instead of stimulating seasonal growth, fires in late spring and throughout the summer will destroy existing growth and can significantly set back both grasslands and forests.

In northern Alberta, the potential for forest fires increases dramatically immediately following the safe-burning period. The driest months of the year are April, May, and much of June, and as forestry records show for recent years, the greatest number of forest fires—sometimes large ones—occur during the latter part of May through mid-June. Although these fires are caused predominantly by humans, they demonstrate the possibility of fire spreading from grasslands to bush after the early weeks of spring. The largest number of lightning-caused fires actually occur later, during the rainy season that extends from the latter part of June through July and August. With the greater heat of the midsummer months, these lightning fires are generally larger and more disruptive.

The act of firing itself—whether it involved a fire drill, flint and steel, or matches—was simple enough, but considerable knowledge was required to carry out controlled burning effectively and safely. Conditions differ from day to day, even hour to hour, and may vary within a single region.

All calculations included the particular time of day. At the onset of spring burning, fires might be set at midday to take advantage of higher tempera-

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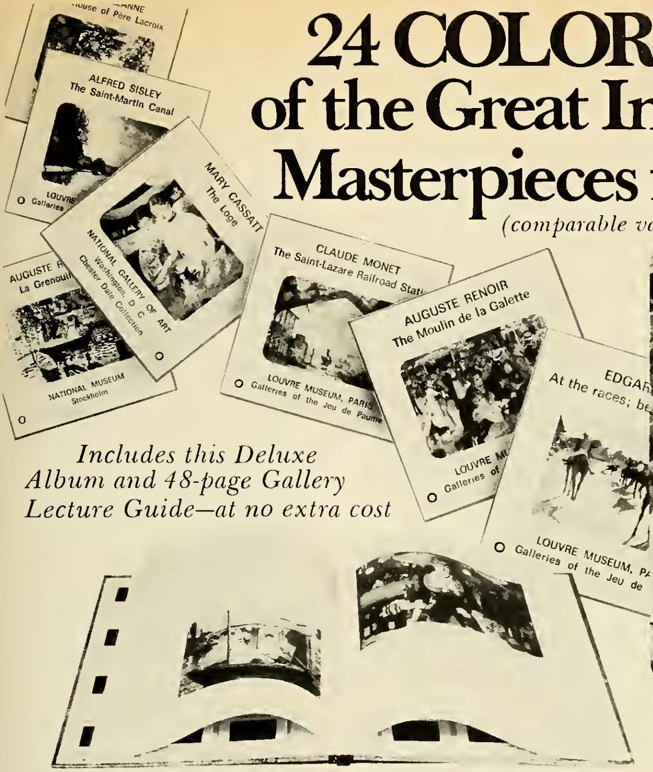

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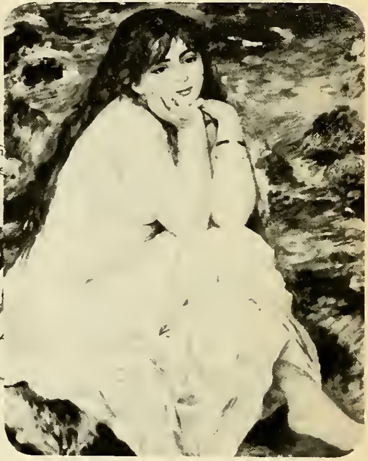

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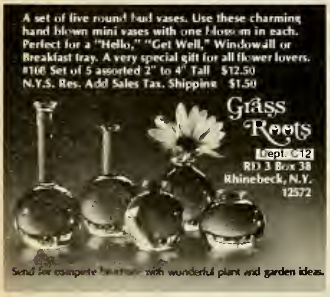

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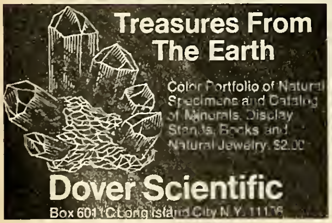

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tures and reduced humidity. A week or two later in the season, fires would be set early in the morning or late in the evening to avoid drier conditions.

The year-to-year frequency with which grasslands were burned was important, since a meadow choked with several years' growth of weeds and brush presented greater problems than one regularly burned. Prairies and meadows with tall, verdant grasses were usually burned each year, whereas the sparser grasses found on sandy, poor soils were fired less frequently. The particular frequency of burning, like seasonality, is distinctively human and sets apart the Indian pattern of burning from the natural cycle of boreal forest fires.

Wind speed and direction were used to advantage, with a moderately strong wind favored for most burns. The overall size of an area was also taken into consideration. A small meadow or slough burned more quickly, reducing the risk that conditions would change before the burn could be completed. Normally, the large prairie-parklands were burned first, and these fires are described as sometimes having lasted several days.

Where the terrain sloped, more intense fires were achieved by burning uphill; less intense by burning down. A Cree-Métis explains:

> See, you start a fire at the top of a meadow in the afternoon, when you feel the wind change, the way the cool air does at that time. This way the fire burns toward the low part of the meadow where all the wet grasses are. And then it just goes out. It's safe. You have to know the wind. You have to know how to use it.

A combination of natural and manmade firebreaks was regularly employed. Streams, lakes, and bogs provided natural barriers, as did the higher humidity levels of brush and trees. Artificial firebreaks included adjacent burned areas, whose relatively drier fuels had been fired several days earlier. Also stands of brush and trees within a previously burned meadow could be intensively fired—sometimes weeks after the initial burn—with the aim of extending the area of grasslands or obtaining ready-dried firewood.

Because Indian campsites were established on the edges of grasslands, the fireproofing of campsites was an integral part of burning meadows and prairies in early spring. To protect the habitations, fires were set so as to first spot-burn within settlements and then burn outward, before running fires were set to clear the adjacent grasslands.

Finally, people could help control fires. Watersoaked spruce boughs were used by women and children to beat out flames at the edges of meadows and around settlements. Besides being relatively ineffective, however, this was considered unnecessary when control factors were understood and "things were done right." Similarly, the modern fire fighting equipment that is deployed at a controlled burn is there, not as part of the controls, but as a safeguard against an escaped, uncontrolled fire.

Although perhaps less than one percent of the total area burned each year, the largest number of fires involved grassy swales and sloughs. Such small fires, which could be carried out by one or two men, were set throughout the areas covered in the annual round of hunting and trapping. These grassy microhabitats within the boreal forest are important for predator and prey alike. A Slavey Indian discusses the concern for maintaining both grass and forested areas:

> Lots of animals that live in the forest come to the meadows and sloughs to hunt. Marten, like, they live in the woods but they hunt lots in the grassy places—specially for mice. So you don't want to burn the woods, just the sloughs and meadows.

The necessary foresight is evident in what another Slavey Indian has to say:

> Trappers burned when they were on their way home from spring hunting. At that time of year it was safe, and they burned because it made it better for them in the winter with more animals to hunt and trap for.

Not infrequently, the hunter-trapper passed through areas before they could be effectively burned, but this problem was partly offset by setting delayed fires. Campfires were left smoldering so that they would flame up when the grasses were sufficiently dry but the forest still wet. This is remembered by a Cree Indian:

> When we'd come off trapline, it might be too wet to burn the sloughs or creeks [creek beds]. So we'd just build a big campfire and leave it. Maybe couple of weeks later even, when the grass is really dry, the grasses would all get burned up, but the fire wouldn't go anywhere because it was still damp in the bush. We didn't worry about campfires in the springtime; but you had to be careful during the summer cause you could start a helluva big fire.

The ponds created by beavers and frequented by moose were of particular value to the Indians. Although some sloughs and streams were burned each year, beaver habitat was burned less frequently, as a Slavey Indian explains:

> It makes a lot of difference for the trapper if an area was once burned. It's easier to attract animals to these areas. As for the beaver, it takes a while before they move into an area that was burned; about four years after the burn. The reason it takes that long for the beaver to come to the burned places is that the aspen don't grow as fast as grass and some other plants that grow after a burn. It is good for the moose too.

Portions of northern Alberta are along the flyways of, and provide summer habitat for, enormous numbers of ducks and geese, and from May through September waterfowl were (and still are) a prime food source. The shorelines of ponds and lakes were fired so as to enhance them for the ducks and geese that fed there. A Slavey Indian describes the process:

> We always burned just before all of the snow melted, before the ducks had started to nest. But we didn't burn after the ducks had nested; we knew when to burn and when not to burn. The spring fires made things good for the ducks, and it was good for all kinds of other animals too.

Muskrat, important for their meat and fur, also depend upon shoreline habitats. "Muskrats like to eat the grass roots, like the reeds that grow round a lake or pond," says a Cree Métis. "When you burn them, the roots grow more and it makes it good for the muskrats." Because the reed and grass fringes of ponds and lakes contain more moisture than the open meadows, they were fired later in the spring burning period. In the absence of regular burning, marshy grasses become matted and die, part of the gradual process by which bodies of water are transformed into grasslands.

Like other forest types, the boreal forests contain deadfall areas where as a result of age, disease, and high winds, trees lie in tangled and nearly impenetrable jumbles. Such areas are all but devoid of game and are likely to ignite during summer lightning storms, threatening to involve the surrounding live forest in dangerous and destructive fires. A Cree Indian explains how, in the spring, the Indians fired such relatively dry deadfall areas:

> When you burn the deadfall places it burns for a long time, not like the meadows—they burn out fast. Because there's all those dead trees. Maybe the next year you come back, burn it some more, and then pretty soon it's all open and the moose really like those places.

As forests age, the intensity of fires increases substantially with the build-up of older trees, dead wood, and decaying plant material. In the normal course of events, older stands of trees and the accumulations of forest-floor litter are periodically removed and the forest thinned or regenerated as a result of lightning fires or, since the arrival of hunter-gatherers in the New World, man-made fires. Our historically recent attempts to eliminate all fires have resulted in greater and greater amounts of fuel and ever larger, more disruptive conflagrations. "This place used to be called First Prairie, and it was all open-like then. But now we got brush, trees, and you get a [summer] fire now and you got a helluva time," warns a Cree-Métis from Hay Lake. "Everything going to get burned up-like. When there were spring fires it wasn't so bad, even maybe you get a summer fire. But now. . . ."

The crown fires that annually destroy hundreds of thousands of acres of timber and brush—sometimes in fire storms with extreme temperatures of 570° to 750°F—were undoubtedly less common prior to 1900. This was because natural fires were unchecked, and because the Indians, through their practices of early spring or late fall burning, added to the diversity of plant communities. What ecologists have now clearly established is that mosaics of young-to-mature plant communities are better protected against the incursions of fire, disease, and bug infestation than are the more uniform, decadent stands of aging brush and trees.

The Indians' knowledge of the use and effects of burning was enriched by their religious and ethical beliefs, in a way perhaps similar to the conservation ethic valued by present-day naturalists. Despite differences in cultural emphases, Slavey, Beaver, Cree, and Chipewyan understood their forest habitats as complex, interrelated systems of causes and effects. They followed a practical, straightforward logic, and as with modern arguments in favor of the use of controlled burning, they recognized that selected and prescribed burning was not simply an imitation of the natural fire regime. "They must be very wise, eh? Those people? That time?" says one Beaver Indian woman. ☐

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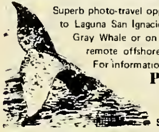

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# A Star in Trouble

*Within our galaxy there is a star with unusual emissions that have puzzled astronomers around the world*

A star unlike any other previously known is under scrutiny by astronomers. Although still preliminary, the studies have inspired several imaginative theories and much commentary in the press. SS 433, as the star is known, has even been the subject of a monologue on the "Saturday Night Live" television program.

The most striking property of SS 433, and the one that has brought it such great notoriety, is the presence in the star's spectrum of pairs of emission lines, instead of single ones, with huge blue and red shifts. These pairs of lines are emitted by hot gas that is streaming away from the star in opposite directions at about one-fourth the speed of light. (The blue shift indicates matter approaching the earth; the red shift, matter receding from the earth. This phenomenon is known as the Doppler effect.) An emission line, a characteristic spectral signature of an element, appears as a bright, thin band in the spectrum—the array of colors, or wavelengths of radiant energy, that we see when white light passes through a prism. Large red shifts have been observed before, in distant galaxies and quasars, but this is the first known case of a large blue shift in any celestial spectrum, and the first case of a large red *or* blue shift in a star within our own Milky Way galaxy.

In the case of SS 433, the pairs of emission lines with red and blue shifts move constantly back and forth along the spectrum. The two lines of each pair always move in opposite directions. Thus the blue- and red-shifted lines of a pair sometimes actually cross each other, so that the hydrogen atoms, say, that were streaming toward the earth then stream in the opposite direction and vice versa.

The moving spectral lines of SS 433 were discovered by a team of California scientists led by Bruce Margon, an energetic young astronomer at the University of California at Los Angeles. After the initial observation was made on August 2, 1978, Margon persuaded colleagues from UCLA and from the Lick Observatory near San Jose, California, to record what he termed the "bizarre" spectrum at every opportunity. The team members ranged from a graduate student to a department chairman. With a battery of telescopes on Mount Hamilton, Mount Palomar, and Mount Wilson in California, and with another telescope on Kitt Peak in Arizona, they were able to observe SS 433 whenever circumstances permitted.

The spectrum of SS 433 is so unusual that at first Margon could not identify the atoms that emit three of the strongest spectral lines, although such identifications are usually duck soup for a professional astronomer. Even the physical process that shifted the lines was uncertain at that time. The California researchers considered the possibility that the familiar Doppler effect was at work; that is, that the line shifts were due to motions of the light-emitting matter. In the case of SS 433, however, the Doppler interpretation seemed unreasonable. The implied velocities of the light-emitting matter and, especially, the changes in velocity from week to week were considerably greater than those found before in any star.

Throughout the fall of 1978, the Californians monitored the curious spectrum of SS 433. Although the puzzling results had not yet been announced, I was given a preview on a late October visit to the control room of the four-meter telescope at Kitt Peak. There, Holland C. Ford, a UCLA astronomer noted for galaxy studies, punched some buttons and two spectra of the star appeared on a computer display screen. Ford had recorded them on two previous nights. Each had a different pattern from any spectrum I had seen before, and the differences between the two were pronounced.

By late fall the California team was examining the possibility that the star might possess an intense magnetic field, perhaps 100 million times stronger than the magnetic field of the earth. In so strong a field, spectral lines can split into pairs, each consisting of a blue-shifted and a red-shifted line. This process, called Zeeman splitting, is named for the Dutch physicist who discovered it when he placed a flame between the poles of a powerful electromagnet.

A second research team was already analyzing a critical test of the idea that Zeeman splitting produces the red and blue shifts in the spectrum of SS 433. According to known physical principles, if an intense magnetic field were present on SS 433, the emission lines would be circularly polarized. In circularly polarized light, the direction of vibration of the light waves rotates like the blade of an electric fan as the light wave travels through space. Led by James Liebert, an expert on polarized light astronomy at the University of Arizona, the second team had searched for circular polarization in the spectrum of SS 433. They found no measurable polarization and began to reexamine the idea that the huge line shifts are produced by the Doppler effect.

In particular, the Arizona group (which also included astronomers from the Universities of Michigan and Toronto) reasoned that if the line shifts were due to the Doppler effect, all the lines should be affected in a similar manner. In other words, if one line were red shifted by 10 percent in wavelength, then every other red-shifted line should be shifted by a like percent. The early Arizona data on SS 433 seemed roughly consistent with this Doppler interpretation, although there were uncertainties. The astronomers felt that they needed further spectra in

**by Stephen P. Maran**

order to tell whether, when the lines moved along the spectrum, their new red shifts would again correspond to equal percentages of their wavelengths. Unfortunately, as the earth revolved around the sun, SS 433 soon became unobservable. In California and Arizona, the two groups impatiently awaited the late winter when, due to the earth's motion, SS 433 would again be in view.

The Arizona team was able to reobserve SS 433 in late February 1979, while the California astronomers did not get a crack at it until mid-March. As Margon later described it to me, the mid-March spectra, obtained at Lick Observatory, had caught SS 433 in a phase when the red and blue shifts were relatively small. Each emission line pair was then closely spaced and there could be no doubt of the true, unshifted wavelengths. This made the identification of the emitting atoms certain. Additionally, it was now obvious that the lines were not simply pairs. They were triplets, each consisting of a central, so-called stationary line, and the noticeably changing red- and blue-shifted members. The pattern was in complete agreement with the expectations of Doppler theory, as was already recognized by the Arizonans, but there was no explanation for the very rapid velocity of the matter that produces the shifting lines or for the changes in the line shifts.

If the Arizonans reached their conclusion first, the Californians had an equally interesting finding. Plotting a graph of the velocities corresponding to all the line shifts on all the dates of observation, they found that the lines were shifting back and forth in a repetitive manner, with a period of about 160 days.

Theoretical astrophysicists struggled to explain what kind of moving, luminous matter might be connected with SS 433 and produce the large and

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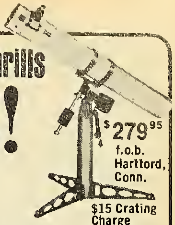

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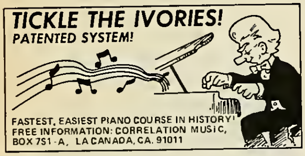

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periodically changing Doppler shifts. One class of theories ascribed the spectral lines and their peregrinations to a thin ring of luminous gas, wobbling in space like the rim of a spinning, leaning top, each wobble lasting 160 days. Matter circulating around the postulated ring at high speed would move toward the observer along half the circuit, producing blue-shifted lines, and then recede around the other half ring, generating red-shifted emissions.

According to the ring theories, as proposed in various forms by theorists in England, Israel, and the United States, SS 433 is a giant black hole, with a mass of 100,000 to a million times that of our sun. Surrounding the hole, it is supposed, is the ring that (depending on which learned speculator one consults) consists either of matter sucked up from the thin gas of interstellar space by the powerful gravity of the black hole or of material drawn out from an unfortunate companion star or planet, doomed to circle the hole as its guts are inexorably extracted by the same immense force.

The menace of a giant black hole can be disregarded, I'm relieved to say, thanks to recent findings by three expert observational astronomers in British Columbia. Led by David Crampton of the Dominion Astrophysical Observatory in Victoria, the three made a detailed study of the "stationary" lines of SS 433. Last August they reported that even these lines shift back and forth in the spectrum, although by rather small amounts. This shifting has a period of thirteen days and almost surely represents the orbital motion of a binary star. Analysis of the orbital motion shows that the two stars in the binary are each no more than about twice as massive as our sun. Thus, the posited enormously massive black hole can be ruled out. Within a week of the Canadian report, the thirteen-day periodicity was confirmed by two physicists from the University of Oregon, who found a variation of similar period in the brightness of SS 433.

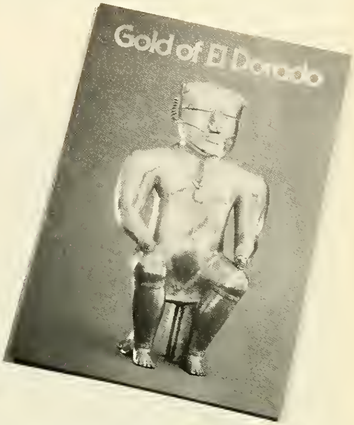
In line with current thinking, one member of the SS 433 binary system is a relatively normal star, while the other is a highly condensed object, probably a neutron star or white dwarf. According to this theory (of which there are several variations), the normal star is losing matter to its condensed companion. As the transferred mass spirals inward to the smaller star, it forms a hot, flat gaseous structure, called an accretion disk. Near the hub of the disk, or perhaps even at the central position of the condensed star, a fraction of the accreting gas is expelled at right angles, above and below the disk, possibly by pressure from gas or radiation or by magnetic forces. At any given time, one jet of gas produces light with blue-shifted spectral lines, as seen from the earth, while the oppositely directed jet emits the red-shifted lines. The accretion disk wobbles, causing the two jets to trace out cones in the sky once every 160 days. Thus, the highly shifted and noticeably changing spectral lines studied by the California and Arizona groups come from the jets of matter. The stationary lines are emitted elsewhere, perhaps from gas streaming between the two stars of the binary system. Such a gas stream would revolve with respect to our line of sight once every thirteen days, as the two stars go around their orbits.

The foregoing is a necessarily condensed account of the findings about SS 433, which is also a source of radio, infrared, and X-ray radiation. The star is under study with a wide variety of telescopes on the earth and in space satellites. From the visible-light studies that I have described, we now know that it is a sort of giant lawn sprinkler in the sky, spraying hot gas out in two revolving streams. The next question is, Where did it come from?

Maps of the surrounding area made with radio telescopes show that SS 433 is in the direction of the central region of a supernova remnant called W50. The latter is the expanding cloud of gas ejected in the explosion of a massive star perhaps 20,000 to 30,000 years ago. It seems likely that the condensed object of the SS 433 binary system is the remaining core of this exploded star. Although a mere cinder of its former self, the core is feeding on the substance of its companion star. This process is inherently unstable and cannot go on forever. By an as yet uncertain means, the core is also converting some of this feedstock into the high-speed jets that wobble slowly as they shoot out into space, signaling across the galaxy that out there, there exists what UCLA's Margon once termed a "star in some terribly weird kind of trouble."

*Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.*

# An Art Book That Took Centuries To Create



It took the American Museum of Natural History four years to arrange its exceptional exhibition of more than 500 pieces of ancient gold from Colombia. But those few years are a brief time when compared with the decades archeologists have spent digging (literally!) and studying the gold artifacts from tombs, caves, and buried sites. And all that time is short when compared with the many centuries prehistoric Indians practiced their craftsmanship and artistry to create these treasures.

So when it became the United States sponsor for this outstanding collection, the American Museum faced a dilemma. Could we do justice to all this effort and scholarship and beauty? We think we have. First, by dramatically displaying *Gold of El Dorado: The Heritage of Colombia* in one of our largest halls. The glowing reports from visitors tell us our efforts have been worthwhile. If you don't have a chance to see the show for yourself in New York, we hope you will see it in Chicago, San Francisco, or New Orleans on its year and a half tour.

The second challenge for the American Museum was the creation of an appropriate book to accompany the exhibition. We decided against a traditional catalog; against a small, boring volume with tiny black-and-white pictures that could never do justice to these fine objects. Instead, we decided to present a select number of the finest pieces of pre-Columbian gold in a large, stunning format. And to represent the three important elements that make a great art book we chose outstanding professionals.

First, photographer Lee Boltin. One of the greatest photographers of art objects, he also took the famous pictures of the Tutankhamun show. We sent him abroad to find and record great pieces of pre-Columbian art.

Second, archeologist Warwick Bray, from the University of London. One of the world's foremost authorities on pre-Columbian art, Bray is also a skilled writer, able to present fascinating background in a succinct, readable essay in the book. Dr. Bray organized the Colombian gold exhibition in London.

Third, Harry N. Abrams, Inc., America's leading publisher of fine art books. In a co-publishing venture with the American Museum, Abrams designed the book, supervised the preparation of 30 large color plates, and monitored the fine-quality printing.

The result is an unprecedented exhibition book. It is bold and big—each plate is 16 by 11½ inches—bigger than this magazine *opened up*. The paper is heavier than most posters. In fact, many persons have purchased two copies of the book in order to have one set of these fine art prints for framing.

And now for the happy ending. Because the Museum is a co-publisher, we are able to offer this soft-bound art book at a major savings from its normal retail price of $12.50. We are pleased to offer *Gold of El Dorado* to subscribers for only $8.95—a 28% savings off its regular price. This special offer is valid only during the exhibition and only while our limited supply lasts. We suggest that you order one or more copies immediately. Of course, if you are not satisfied after you have had an opportunity to examine it in your home, simply return the book and the Museum will refund the purchase price.

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# Celestial Events

### by Thomas D. Nicholson

**Sun and Moon** The sun is in the constellation Sagittarius in early January, moves into Capricornus on about the 19th, and into Aquarius by mid-February. Although the sun passed the winter solstice on December 22 (the "shortest" day of the year), the latest sunrise doesn't occur until January 4. While the time of sunrise changes little in January, sunset will come noticeably later, causing daylight to lengthen rapidly in the evening.

The moon is nearly full at the beginning of the month and quickly moves into the morning sky. It will present an exceptional view as it moves past Regulus, Mars, Jupiter, and Saturn from January 5 to 9 and again from February 1 to 4. January phases are: full on the 2nd, last-quarter on the 10th, new on the 17th, first-quarter on the 24th, full again on the 31st. In February, last-quarter is on the 9th, new moon on the 16th. Apogee (when the moon is farthest from the earth) is on the 8th in January, 4th in February. Perigee (nearest the earth) is on January 19 and February 17.

**Stars and Planets** Venus is brightening and moving into the part of the ecliptic that keeps it high above the horizon after sundown. It becomes very prominent in January, appearing higher and remaining later each night. Look in the west soon after sunset. After Venus sets, look for Mars, Jupiter, and Saturn to rise in the east, beginning about 9:00 P.M. Those three objects, together with the star Regulus to their right, make an exceptional sight from about 10:00 P.M., when they are well up in the southeast, until dawn. Jupiter is the brightest among them, Mars is next and brightening rapidly; Regulus to their right and Saturn to their left are about equally bright.

January 3: The earth is at perihelion, nearest the sun.

January 5–9: The waning moon is nearest Regulus on the night of the 5th, Mars and Jupiter on the 6th, and Saturn on the 7th and 8th.

January 7: Saturn begins its retrograde (westerly) motion.

January 17: Mars begins its retrograde motion. All three planets in the late night sky, Mars, Jupiter, and Saturn, are now moving westerly (retrograde). This will take all of them slowly closer to the star Regulus, while Mars moves closer to Jupiter, and both Mars and Jupiter move slowly away from Saturn. You can readily see these changes taking place if you watch them during the weeks ahead.

January 19–20: The crescent moon and Venus will present an interesting view in the early evening sky.

January 21: Mercury is at superior conjunction, in line with but beyond the sun, and it now enters the evening sky.

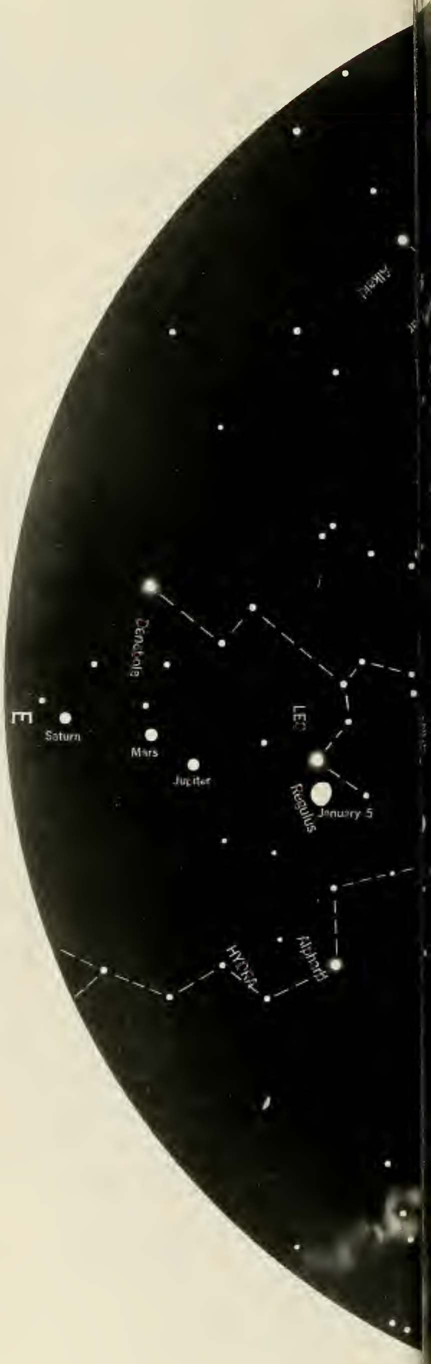
January 26: The bright star near the moon is Aldebaran in Taurus. About midnight, the moon covers Aldebaran, an occultation visible to observers in the southern United States.

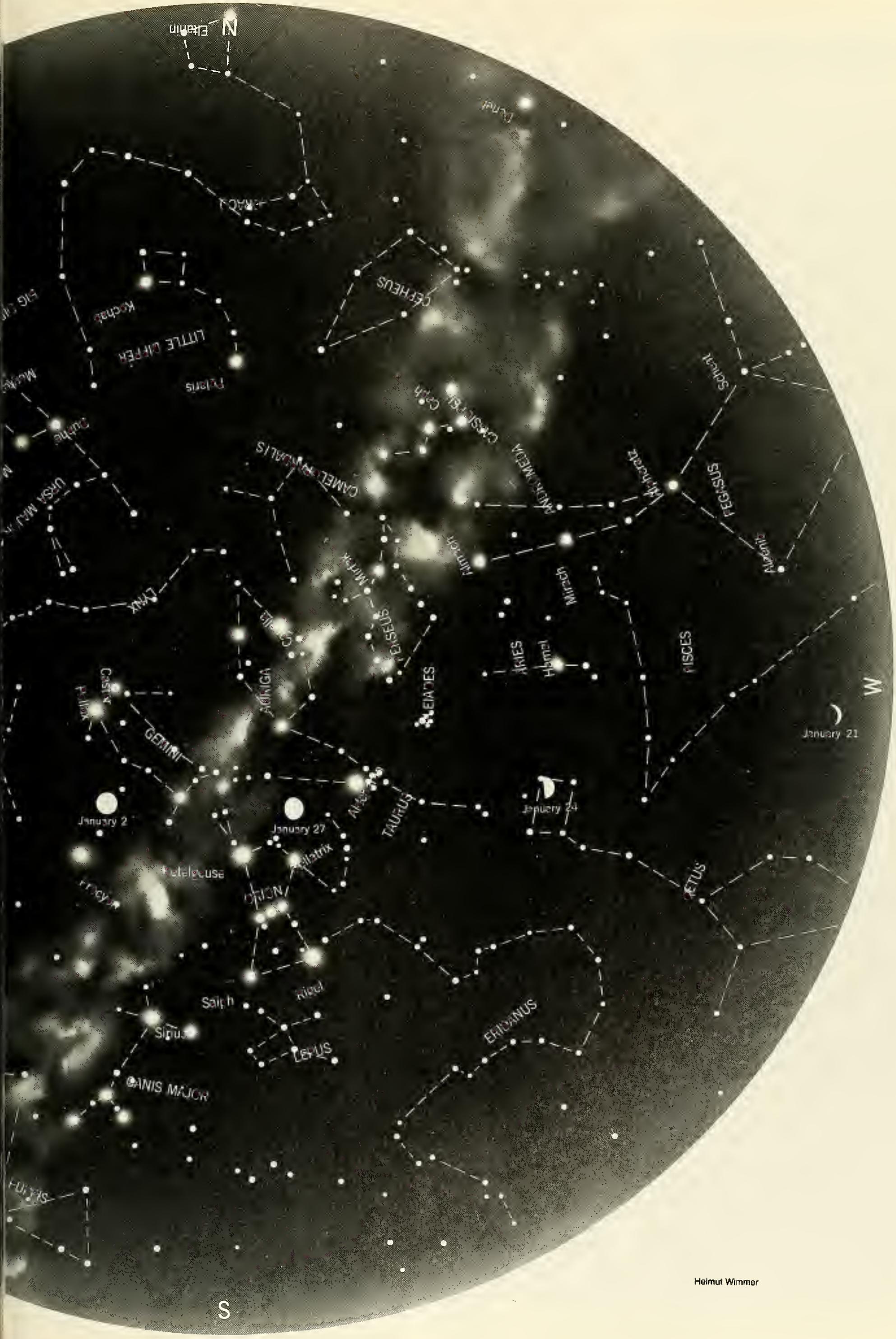
February 1–4: The moon again moves past Regulus, Jupiter, Mars, and Saturn, presenting a dramatic view each successive night from about 9:00 P.M. until dawn. The three planets and Regulus are even closer to one another than in January, and Jupiter and Mars are exceptionally bright.

February 16: A total solar eclipse occurs today in Central Africa. It will be partial over large areas of Europe, Africa, and Asia.

February 17: Perigee moon occurs 24 hours after new moon, enhancing the normally stronger spring tides today.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on January 1; 10:20 P.M. on January 15; 9:15 P.M. on January 31; and 8:15 P.M. on February 15; but it can also be used for an hour before and after those times.

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Helmut Wimmer

# At the Museum

## *Gift of Akeley memorabilia includes unpublished Congo journals*

On the last page of the 1977–78 Annual Report of the American Museum of Natural History is a short list of "Gifts-in-Kind, Over $1,000" that includes, among other things, "one carved skull rack from the Papuan Gulf," "six jeremejevites," "92 snuff bottles," and "notebooks, pictures, and other memorabilia of the late Carl Akeley."

Carl Akeley, as many Museum visitors know, designed and collected for the Akeley Hall of African Mammals. In the early 1920s he revolutionized the art of taxidermy by replacing the traditional stuffing—which became lumpy and insect infested over time—with a sculptured model of the animal's body over which the skin was stretched. To mount the Museum's African elephants, Akeley invented a mechanism that combined cement with air and sprayed the foamlike mixture on a supportive frame. Dissatisfied with the movie cameras he used on his first African expedition, he designed and built one more to his taste; with it he took the first motion pictures ever made of gorillas. Akeley died in 1926 while on a collecting expedition in Africa.

The Akeley memorabilia, a gift from the estate of Akeley's second wife, Mary L. Jobe Akeley, arrived late in 1977 in two cardboard boxes, which were stored in a dark corner of the Rare Book Room. The boxes were opened, but nothing was removed or cataloged until last fall, when Nina Root, the chief librarian, decided to examine their contents.

The boxes were filled with yellowing folders stuffed with letters and notes, crumbling journals and notebooks held together with silk ribbons, hand-tinted glass lantern slides, photographs, newspaper clippings, and autographed books.

Most of the material, it turned out, did not concern Carl Akeley at all, but Mary L. Jobe Akeley—a well-known explorer, mountaineer, and educator, who had already led six expeditions to the Canadian Northwest before she married Akeley in 1924. Mary L. Jobe was the first person to map the headwaters of the Fraser River and the glaciers of Mount Sir Alexander. She had made several first ascents, and the Canadian government christened a peak in the Rockies "Mount Jobe" in her honor. Like most explorers, she kept notebooks while in the field. In one small notebook, marked *1917–18 Trail Notes Enroute. Wapiti*, she had recorded the progress of an early expedition to Alberta. Every square millimeter of the notebook was filled with a dense, almost illegible hand.

> Oct. 15. Rode up to timberline at snow line—It began to snow—[illegible] Blue horse played out—Steep going—Drifts waist deep—fell every 10th step—C. hardly make Blue go—Finally made summit—Heavy snow. . . . Steep coming down—Fell over rock head down—6 ft—Black & blue—Jack falling constantly—Horses overtired. . . .
>
> Oct. 17. Awake at 6—Not a great deal of sleeping—Much groaning—Very snowy but clear—Temperature 16° above zero—Breakfast of bacon, peas, green [illegible] flap jacks. . . .
>
> Oct. 18. C. up at 5:30—I lay until 6:15—H.G. terribly cold all night—slept little—Jack awake and groaning most of night—Dreamed of eating chicken at the Mitchell's. . . .

Six years and several expeditions later, Mary L. Jobe married Carl Akeley, and some of her notebooks did concern him. In 1926 she accompanied him on the Akeley-Eastman-Pomeroy Expedition to West Africa to collect and photograph for the proposed African mammal hall at the Museum. A bundle of journals, tied with a red silk ribbon, covered this expedition. Inside the front cover of the last journal was scribbled, "Kivu—High Camp on Slopes of Mt. Mikeno. Nov. 14 et Seq."

> [Nov. 14, 1926] It was cold & it poured rain. With the exception of a few moments of sunshine each day, where for a brief period the clouds lifted so that we could see Lake Kivu and also the two volcanoes Nyamlagira and Nyiragongo. The craters we could see plainly almost every night as its fiery furnace of boiling lava illuminated the clouds & sky or as flames shot into the heavens. . . .
>
> Looking out of my tent it occasionally seemed as if I were standing on the brink of a gulf. The clouds were so dense & as if the whole world were falling away from me—at such times I could hear the song of the thrush. . . .

The expedition stayed for several days at a camp on the saddle between Mount Mikeno and the volcano Karisimbi. Akeley was nauseated but insisted on moving to their next camp.

> When about ¼ mi. away from the saddle camp he [Akelely] stopped the boys & said he was cold & would wait. It was dismal, wet and dark just there so he walked back to camp & sat down under the fly of the work tent. . . . He talked energetically about the gorillas there. . . . Soon he began to shake with a chill. In about half an hour he began to get worse—then [illegible] fever came & he ran a temperature of 103. This I controlled & in about three hours, a little after dark, he was normal. . . . The next morning [Nov. 16] he said he had not slept at all & was again nauseated & could take no nourishment. . . . There was a

**Evening Lecture Series**

Africa has long served as a vast, outdoor laboratory for the study of animal behavior. Richard Van Gelder will lead off the "Winter 1980 Adult Evening Lecture Series" with *The Greatest Show on Earth*. In eight slide-illustrated lectures, Van Gelder will expose the private lives and loves of a wide variety of African mammals, from the matriarchies of elephants and the harems of baboons to the solitary habits of leopards and the hunting-pack strategies of wild dogs. Van Gelder travels frequently to Africa, both for the Museum's Discovery Tour program and as a research scientist and curator in the Department of Mammalogy.

In a second series, Malcolm Arth, anthropologist and curator in the Department of Education, will explore a wide range of human behavior in the 1980 "Anthropology Through Films" program. The featured guests will be filmmaker-anthropologists who will discuss their work and answer questions from the audience. In one program, Robert Gardner will show *Deep Hearts*, his new film about a ceremony among the Bororo people of Niger in which men compete to be selected as the most nearly perfect. On another evening, guests David and Judith MacDougall will screen and discuss their 1976 film, *The Wedding Camels*, which reveals the complex progress of a marriage in the making among the Turkana people of East Africa.

These are just two of the many

heavy hailstorm. I kept Carl warm and gave him hot water which was all he could take. I said to him in the A.M., "Well, I have got them all hard at work, if that is any consolation." He said, "It doesn't seem to matter now. But out it will in the long run. I know." I asked him, when [illegible] if he wanted me to stay with him—if "he were afraid." He laughed a little laugh and said, "No honey, I am not afraid."

[Nov. 17] From 9 to 11:30 he seemed quite comfortable but very weak. . . . I propped him up on extra pillows & put pillows under each arm. His eyes seemed looking far up Karisimbi. . . . I could still feel his pulse faintly in his wrist but more pronounced in his neck. Derscheid [a Belgian zoologist and doctor who accompanied the expedition] gave him more caffeine, believing he was in a stupor. But as he never reacted to it, his soul must have passed. . . . It was not, however, until 2:30 that we could believe he was gone. . . . For four days our boys worked excavating a tomb for him out of the lava rock on a high point above our tents. . . .

After Carl Akeley died, Mary Akeley took charge of the expedition; for five more weeks she continued to collect and photograph despite torrential rains and the desertions of workers. When she returned from Africa, King Albert of Belgium called her to Brussels and bestowed upon her the Cross of the Knight of the Order of Belgium in recognition of her achievements.

Mary Akeley explored, collected, and mapped in the Congo, Zululand, the Transvaal, East Africa, and Canada until age forced her to limit her activities. She was 80 years old when she died in Mystic, Connecticut, in 1966.

If you visit the Museum you can glimpse the two volcanoes Mary Akeley describes in her journal. In the Akeley Hall of African Mammals, behind the magnificent gorillas collected and mounted by Carl Akeley, there is a panoramic view of Nyamlagira and Nyiragongo. The painting is based on a photograph Akeley took near the spot where he was later buried. Once while passing this break in the trees, which he thought was the most beautiful spot in all of Africa, Akeley turned to his wife and said, "Do you see now where the fairies dance?"

*Douglas J. Preston*

lecture series and field trips offered by the Department of Education this winter and spring. To obtain a brochure and registration form for the lecture series and field trips, write to the Department of Education at the Museum or call (212) 873-7507.

**Discovery Tours**

Participants on the Museum's 1980 *Voyage to Classical Lands* depart February 20 aboard the m.t.s. *Orion* to visit Egypt and Israel. Accompanied by Museum scientists and lecturers, tour members will learn about the history, archeology, and geology of the area as they cruise through the Suez Canal and into the Gulf of Aqaba. Prices, which include air fare, range from $2,700 to $3,300 per person, double occupancy.

The *Orion* is one of many ships the Museum has engaged for its 1980 Discovery Tour program. Travelers on the *Nile Cruises* (several are offered) will board flat-bottomed boats and sail up the Nile River, visiting Thebes, Karnak, the Valley of the Kings, and other historical sites. In September, ornithologist Mary LeCroy will lead tour members on a houseboat trip down New Guinea's Sepik River as part of the *Anthropology and Ornithology Tour of New Guinea and Australia*. Participants on the *Mongolia and Central Asia* tour in June will take to the water to explore the natural history of Lake Baikal in Irkutsk, Siberia.

For more information about tours and itineraries, write to Discovery Tours at the Museum.

**Music of the Andes**

*Tahuantinsuyo*, a group of traditional musicians from South America, will offer an evening of music from the Andes on Wednesday, January 9, at 7:30 P.M. in the Auditorium. The program will be accompanied by dances from the highlands of Colombia and slides of the life and scenery of the Andes. Tickets for *Tahuantinsuyo* are $7.00. For information on ticket availability call (212) 873-7507.

**Guided Tours**

The Museum offers free tours, led by Museum volunteers, to give visitors an inside glimpse of the history of the Museum and to provide an introduction to the Museum's vast collections. Visitors may join the *Highlights and History Tours* at the second floor Information Desk in late morning or early afternoon. Inquire at the desk for specific times on the day of your visit.

**Worlds in Balance**

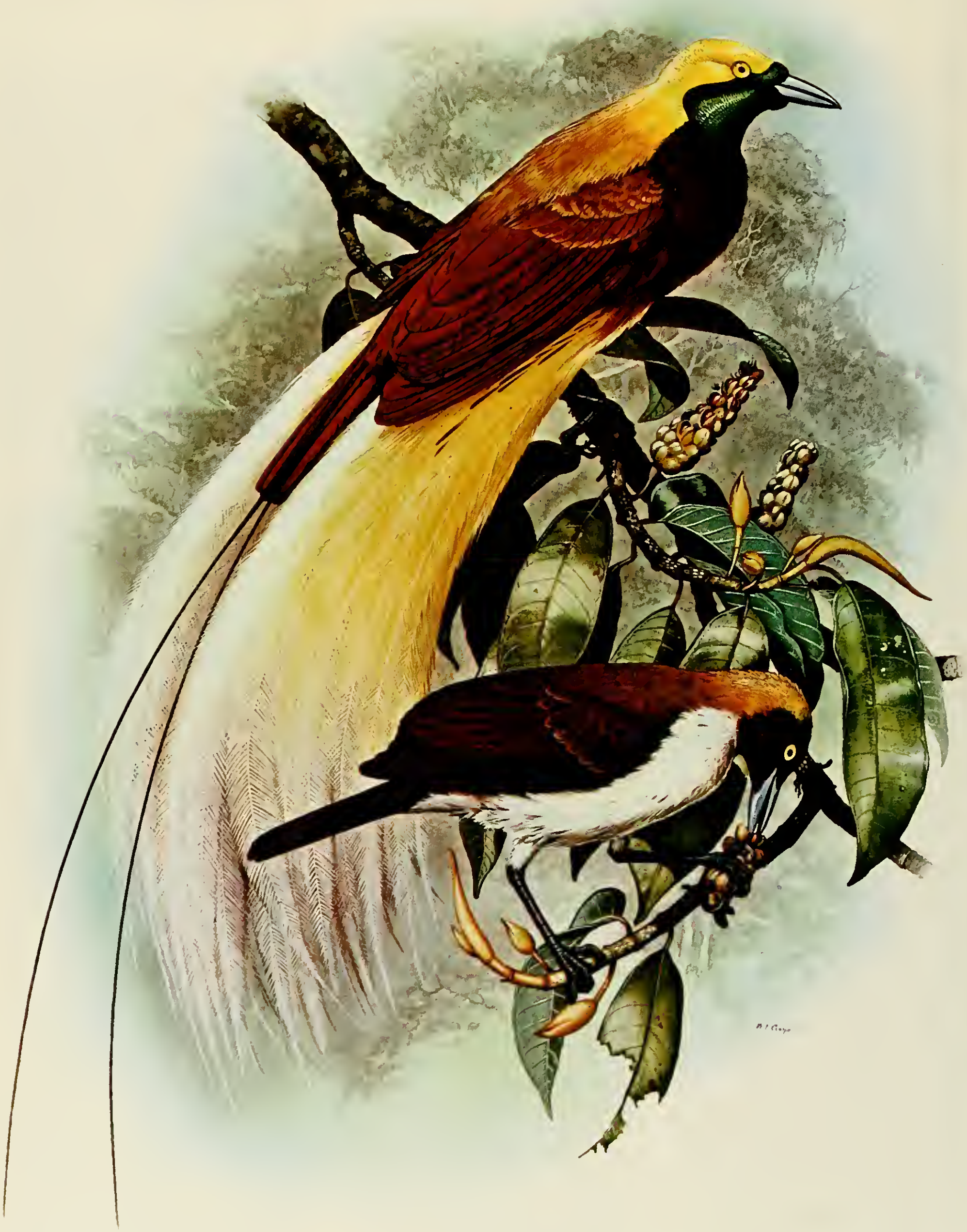
For the January Members' Program, George Schaller, author of *Mountain Monarchs* and other books on endangered habitats, will compare two widely different ecological systems and the challenges they offer to scientists, governments, and conservationists. The swamps of the Mato Grosso south of the Amazon and the fragile environment of the high Himalayas will be the subjects of his slide-illustrated talk, for which he will draw on his own scientific work and conservation efforts in both areas. *The Himalayas and the Amazon: Endangered Habitats at Two Extremes* will be presented on Wednesday, January 16, at 7:30 P.M. in the Auditorium. Members are admitted free; nonmembers may purchase tickets for $3.00 at the door.

**Puppet Show**

Puppeteer Eric Bass will present *The World of Little Kasper* on Sunday, January 20, at 2:00 P.M. in the Auditorium. The show, for children over six and adults, is a series of tragicomic vignettes featuring Little Kasper, a three-foot puppet character based on a German folk hero. Little Kasper sings, dances, plays the xylophone, and experiences the vicissitudes of life. Phyllis A. Ehrlich in the *New York Times* calls *The World of Little Kasper* "sophisticated and humorous." Members are admitted free; nonmembers may purchase tickets for $2.50 at the door. For more information, call (212) 873-1327.

**The Big Step**

*Colony in Space* will return to the Hayden Planetarium after *Star of Wonder* closes January 8. *Colony in Space*, which premiered at the Planetarium last September, explores how human beings may first colonize outer space in the early twenty-first century.



*Lesser Bird of Paradise*

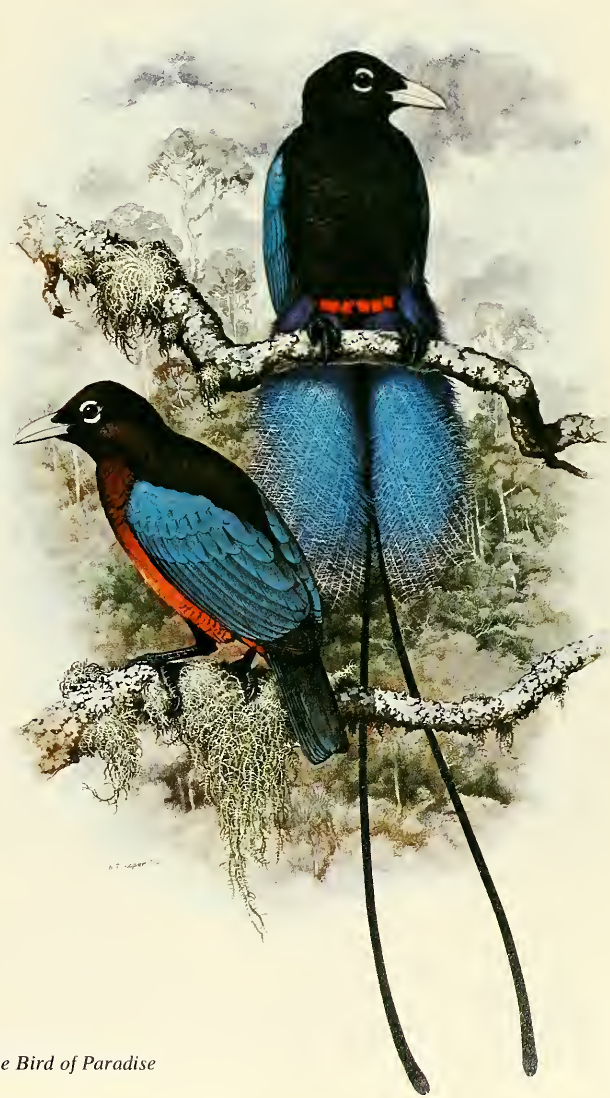
by Mary LeCroy

# New Guinea Jewels

The Birds of Paradise and Bower Birds, by William T. Cooper and Joseph M. Forshaw, *David R. Godine, Publisher, $150.00; 304 pp., illus.*

An exquisite folio volume, *The Birds of Paradise and Bower Birds* is now available in the United States for the first time, although it was originally published in Australia in 1977. David Godine is well known in this country for publishing fine books, and the present volume is no exception. It immediately invites comparison with nineteenth-century volumes featuring hand-colored lithographs. More specifically, from 1891 to 1898 Bowdler Sharpe published a monograph on birds of paradise and bower birds using plates prepared by the then recently deceased John Gould and adding plates by other artists. This treatise was very expensive even then and a limited number of copies were produced. The few complete sets that remain are for the most part difficult of access. Since then no volume has accurately portrayed the birds of paradise and bower birds in color.

William Cooper's paintings are in many ways reminiscent of Gould's—a distant, pastel forest shrouded in mist forms a backdrop for the brilliant, jewellike colors of the birds themselves. The earlier artists had meager knowledge of the birds in life and had to rely on museum skins and snatches of field notes, but Cooper has made a number of trips to Papua New Guinea to study the birds in their natural habitats. His plates reflect this firsthand knowledge not only in the birds themselves but also in the vegetation, the candid pencil sketches, and the many field notes quoted in the text. Having seen the original paintings for this volume, I can appreciate that some of the subtleties of color, iridescence, and



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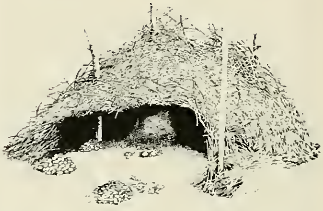
deep, velvety black are lost in the printing process. But I doubt that any greater fidelity to the original is possible, short of the hand-colored plates of the last century. The present plates are very beautiful indeed, and the edition is a collector's item.

Joseph Forshaw states in the introduction that this volume is designed to supplement and illustrate in color the standard work on these two families, *Birds of Paradise and Bower Birds*, by E.T. Gilliard (Natural History Press, 1969), which is still available. Therefore, much of the material covered in the Gilliard volume and most of the theoretical considerations are omitted from the present work. An introductory chapter orients the reader, and write-ups of individual species give a good general account of subspecies, distribution, general life history, and reproduction. Included in these species accounts is much recent (post-1969) information, some presented here for the first time. Of particular importance are Cooper's recent field observations of display and mating sequences of several species.



This, then, is not just a picture book. Although the text is in one sense a vehicle for the plates, the plates and text together make it possible, for the first time in two generations, for the public to glimpse the almost unbelievable beauty, diversity of form, and unique behavioral patterns of these two fascinating families. Unfortunately, the cost will put this volume out of the reach of many, but we may hope that a smaller, less expensive edition will be forthcoming, as was the case with Forshaw and Cooper's *Parrots of the World*. The new information in the text deserves a wider audience.

*Mary LeCroy, a member of the scientific staff of the Department of Ornithology at the American Museum of Natural History, is the author or coauthor of fourteen articles on New Guinea birds.*

# EVENING LECTURE SERIES FOR ADULTS STARTING FEBRUARY, 1980

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**ANTHROPOLOGY THROUGH FILMS**—6 Thursdays starting February 14, 7:00-9:00 p.m. Fee: $35. Main Auditorium.

Six evenings of extraordinary films selected and discussed by Dr. Malcolm Arth, anthropologist and curator, which provide insight into culture and human behavior. Filmmakers John Cohen, Robert Gardner, David and Judith MacDougall; and anthropologist Rhoda Metraux will be special guests during the series which includes the films: Qeros: The Shape of Survival; Eduardo The Healer; Italian-American; Cotton Candy and Elephant Stuff; Deep Hearts; Reflections: Margaret Mead; and The Wedding Camels.

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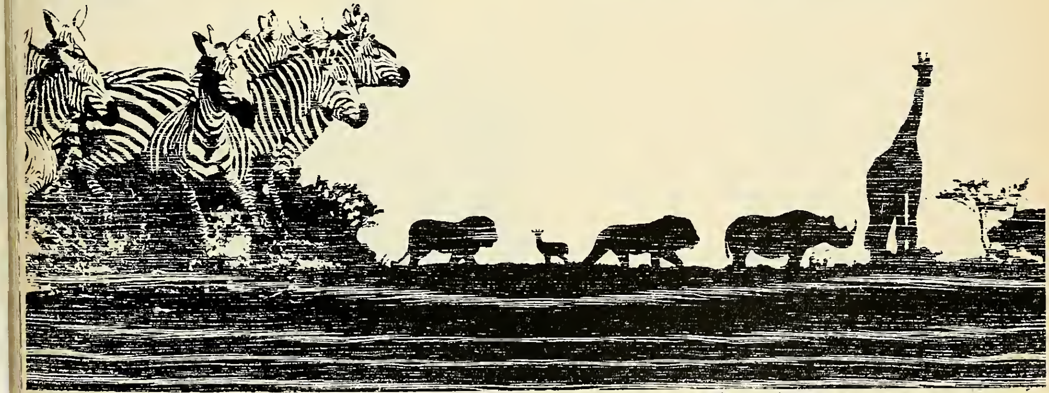
**ANIMAL LIFE IN NORTHEASTERN UNITED STATES**—8 Thursdays starting February 14, 7:00-8:30 p.m. Fee: $40.

Using color slides and recordings, Kenneth A. Chambers, Lecturer in Zoology at the Museum and author of *A Country Lover's Guide to Wildlife*, introduces the exciting variety of amphibians, reptiles, birds and mammals to be found in the New Jersey Pine Barrens, the Adirondacks of New York, and other remote areas in New England.



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# Additional Reading

**Desert Shrew** (p. 46)

A summary of scientific data and references on the desert shrew can be found in "*Notiosorex crawfordi*," by David M. Armstrong and J. Knox Jones, Jr. (*Mammalian Species*, November 29, 1972, pp. 1–5, published by the American Society of Mammals). *Sierra Nevada*, a natural history of the desert by Verna R. Johnston. (Boston: Houghton Mifflin Co., 1970), has a small section on shrews. The biological rhythms of dusky shrews are discussed on page 96 of *Mammals of the Pacific States*, by Lloyd Ingles (Stanford: Stanford University Press, 1965). Illustrated by the author, Konrad Z. Lorenz, *King Solomon's Ring* (New York: Apollo Editions, 1961) is an anecdotal natural history of a variety of animals, including shrews. *Desert Animals: Physiological Problems of Heat and Water*, by Knut Schmidt-Nielsen (Oxford: Clarendon Press, 1964), explains how animals survive in the desert. "Of Libyan Jirds and Fat Sand Rats," by Martin Daly (*Natural History*, February 1979), is about another small desert animal.

**Spiders** (p. 56)

A classic natural history of spiders by the great nineteenth-century naturalist J. Henri Fabre, *The Life of the Spider* (New York: Horizon Press, 1971) gives detailed descriptions of the curiosities of spider behavior. *The Common Spiders of the United States*, by James H. Emerton (New York: Dover Publications, 1961), is an introduction to American spiders (first published in 1902 by Ginn and Company). Spiders' habits, life histories, morphologies, numbers, and kinds are discussed in *American Spiders*, by Willis J. Gertsch (Princeton: D. Van Nostrand Co., 1949). *The Spider Book*, by John Henry Comstock, revised and edited by W. J. Gertsch (Ithaca: Cornell University Press, 1975), is a guide for amateurs and beginning students to the structure, habits, and classification of American arachnids (first published in 1912). An inexpensive guide is *How to Know the Spiders*, by B. J. Kaston (Dubuque: William C. Brown Co., 1978). For scientific articles see the *Journal of Arachnology*, published three times a year by the American Arachnological Society in cooperation with the Graduate School, Texas Technological University.

**Galápagos Fish** (p. 62)

"The Eye Structure of the Four-eyed Blenny, *Dialommus fuscus* Gilbert," by C. M. Breder, Jr., and E. B. Gresser (*Zoologica*, vol. 24, 1939, pp. 239–44), was the first published anatomical description of the species, based on a preserved specimen. J. B. Graham's "Aerial Vision in Amphibious Fishes," (*Fauna*, vol. 3, no. 1, 1971, pp. 14–23), is a colorfully illustrated review of amphibious and aerial vision. Other marine creatures of the Galápagos Islands are featured in "Undersea Wonders of the Galápagos," by Gerard Wellington, with photographs by David Doubilet (*National Geographic*, September 1978, pp. 363–81). See also "The Four-Eyed Fish Sees All," by Thomas O'Neill, with photos by Paul A. Zahl (*National Geographic*, March 1978, pp. 390–95). *Galápagos World's End*, by William Beebe (New York: G. P. Putnam's Sons, 1924), is a readable natural history with some discussion of marine life. More scientific, *The Galápagos: Proceedings of the Symposia of the Galápagos International Scientific Project*, edited by Robert I. Bowman (Berkeley: University of California Press, 1966), includes papers on Galápagos sea life.

*Boeotian female clay figure, seventh century* B.C.

M. Chuzeville, Musée du Louvre

**Swastika** (p. 68)

Most available books about swastikas are reprints of earlier works. *The Swastika*, by Thomas Wilson (Washington: Smithsonian Institution, 1896), covers description, origin, and dispersion throughout the world and contains an extensive annotated bibliography and many illustrations. *The Migration of Symbols*, by Eugene F. Goblet D'Alviella (New York: Burt Franklin Publishers, 1972), devotes a chapter to the swastika, which discusses geographical distribution, interpretation of meaning, history of use, and origin (reprint of the 1894 edition). The first chapter of *The Migration of Symbols and Their Relations to Beliefs and Customs*, by Donald A. Mackenzie (New York: AMS Press, 1970), also deals with the meaning, distribution, and use of the swastika (reprint of the 1926 edition). Further background on Hindu astronomy and the nine planetary gods can be found in *A Historical View of the Hindu Astronomy from the Earliest Dawn of That Science in India to the Present Time*, by John Bentley (New York: International Publications Service, 1970), a reprint of an 1825 edition.

**Indian Fire Ecology** (p. 76)

*Fire and Ecosystems*, edited by T. T. Kozlowski and C. E. Ahlgren (New York: Academic Press, 1974), is a collection of papers on both harmful and beneficial effects of fire on a variety of soils, soil organisms, birds, mammals, and plants. A useful monograph available from Canada's Minister of Supply and Service is *The Effects of Fire on the Ecology of the Boreal Forest, with Particular Reference to the Canadian North: A Review and Selected Bibliography, Occasional Paper No. 32*, by John P. Kelsall, E. S. Telfer, and Thomas D. Wright (Ottowa: Canadian Wildlife Service, 1977). *Man's Role in Changing the Face of the Earth*, edited by W. L. Thomas (Chicago: University of Chicago Press, 1971), has a chapter, by Omer C. Stewart, on "Fire as the First Great Force Employed by Man."

*Katharine D'Agosta*

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# Tasty Pasty

*In Michigan, a Cornish delicacy is given a Finnish flavor*

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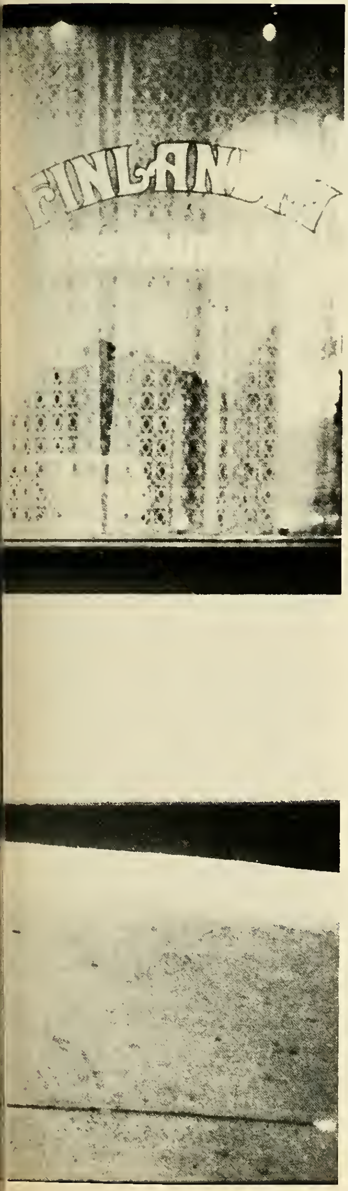
Photographs by Dan Seifert

by Raymond Sokolov



*The Finlandia Bakery caters to the tastes of the Upper Peninsula's Finnish population. Here local Finns can purchase sweet Finnish cardamom bread, as well as excellent Cornish pasties.*

Anyone who thinks that ethnicity in America is a simple matter should make a trip to the copper country of Michigan's Upper Peninsula. There are other reasons for visiting the area: grand stretches of unsullied northern woods, the oceanic expanse of Lake Superior, wild rivers like the Yellow Dog. But eventually the most ardent outdoorsman will stop for a sample of Superiorland's most typical local food, the pasty, a large half moon of short pastry filled with chopped meat and vegetables.

The pasty (pronounced pass-tee) is as much a feature of the Upper Peninsula landscape as the white pine. In 1968, sidestepping pressure to name it the state food, Gov. George Romney went so far as to declare May 24 Michigan Pasty Day. Madelyne's, the pasty world's equivalent of Stouffer's, passed the million-pasty mark years ago at its Ishpeming factory, and independent pasty shops punctuate the fir-lined highways. It was in such a place that I—then just a boy with boyish notions—first bit into a pasty. I stepped up to the counter and asked for a "pays-tee," only to realize from the smirk on the waitress's face that I had made a ludicrous error. The kind of pasty I had asked for was available only in shops specializing in the accouterments of what is politely termed exotic dancing. My other mistake was more sophisticated: I assumed I was eating a Finnish delicacy.

The copper country is a Finnish enclave. People with Finnish surnames abound, descendants of turn of the century immigrants who came to work the iron and copper mines or to clear the land and farm it. At Hancock, Finnish Lutherans established Suomi College. Suomi is the Finnish name for Finland; it is also the name of a small upper Michigan village. At one time, the Upper Peninsula was a hotbed of Finnish-language theater and newspapers, fraternal lodges and mutual aid societies. Much of this has vanished, but the Lutheran Church in Gwinn still holds a service in Finnish once a month. In 1976, Central Upper Peninsula Finnish-Americans united in a special bicentennial celebration. And in downtown Marquette, the Upper Peninsula's largest town (population 22,000), there is a restaurant and bakery called Finlandia.

When I first stopped there in the mid-seventies, the owner had a Finnish name and served Finnish specialties, such as the flat rye bread called *rieska*, as well as excellent pasties. Even today, when the new owner describes himself as "half-French, half-Polack," a sign on the wall thanks customers in Finnish (*kiitoksia*) and sells a sweet Finnish cardamom bread. There are still pasties, too, but they are no more Finnish than lasagne.

The Michigan pasty was long ago adopted by local Finns, but it came to the state with the Cornish miners who arrived about 1850. Their big hot pies were the ideal portable lunch: you could carry them in your pocket all morning, enjoying their warmth, and then you could eat them with your hands, holding them upright so that the juices drained to the bottom as you worked from one end to the other.

Although there is no real doubt in anyone's mind that the Cornish Cousin Jacks and Cousin Jennies (as Cornish people are known colloquially) were the original pasty makers in Michigan, the inquiring gastroethnographer can uncover earlier, more widespread sources for the dish. Pasties are mentioned in Middle English literature written outside Cornwall. Chaucer and Gower knew about pasties. Later on, Shakespeare's Mistress Page, in *The Merry Wives of Windsor*, offered a

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*The pasty was probably brought to Michigan by Cornish miners who were called Cousin Jacks and Jennies. This restaurant in Marquette acknowledges the pasty's origin.*

''hot venison-pasty'' to Falstaff. Neither Windsor nor the Globe Theater of Elizabethan London was a center of Cornish culture. Indeed, the word *pasty* obviously derives from the same Late Latin word for dough as such modern terms as *pasta, pâté*, and *pâte*, all of which have to do with moistened flour, paste. And even the idea of a free-standing meat pie surrounded by dough has been universal in Europe from the medieval period to modern times.

In Finland, for example, in the eastern district of Karelia especially, there are many kinds of small, filled pastries. In *The Finnish Cookbook*, Beatrice Ojakangas gives recipes for rye-flour pasties, sometimes baked, sometimes fried, with a slit in the middle. Some are stuffed with ground meat, some with carrots, some with salmon fillets, some with cabbage. The Finnish name for this family of stuffed pasties is *piirakkaa*, an obvious cognate of the Russian word for filled dumpling, *pirog*. Finland's border with Russia has swung back and forth over the centuries, and the food of Karelia is heavily Russified. But the Finnish culinary imagination has put its own stamp on the Karelian cuisine. No one can say with certainty if *piirakkaa* or *pirog* came first.

But just as the Cornish immigrants to Michigan considered *their* pasties to be theirs, the Finns must have thought that the filled pies they had learned to make in the old country belonged by inheritance and tradition to them. Yet, with the exception of a rarely seen, rye-crusted fish pie called *kalakukko*, the Finnish pasties of Finland do not seem to appear on the tables of Michigan Finns.

Latecomers to the shores of Lake Superior, the Finns found Cornish Cousin Jacks already well established in the mines. The Cornishmen had the advantage of speaking English (or at least a special version of it) from the start, and they were often foremen supervising Finns. Like other immigrant groups, the Finns rapidly adapted to the new culture they found in the Upper Peninsula. One of the lessons they learned was how to cook the locally well-entrenched Cornish meat pie.

Bertha Hill, for example, learned to make Cornish pasties from her mother, who was born in Finland. But she also learned regular Finnish dishes, such as the baked cheese, *juustoa*, and the oven ''pancake'' called *kropsua*. She grew up in a bicultural world, speaking English and Finnish, cooking in two styles. But in her lifetime, she has felt strong pressures at work undermining the strength of the Finnish component in her background. Her name, Hill, is a translation of a common Finnish surname, Maki. Her son, who learned to speak Finnish at home, was so mercilessly mocked at school that he dropped the language completely and simply refused to use it.

Today, Mrs. Hill runs the kitchen at a nearby country school and lives on an eighty-acre, former homestead farm, where she sometimes bakes in the oven of a white porcelain, old-fashioned Monarch wood-burning stove. Her pasties (see recipe) are better than any of the commercial pies I sampled on a recent trip to the Upper Peninsula, better even than the pasties at Kuz'n Jax in Marquette. This is partly the result of her skill as a baker and partly because all her ingredients—from the vegetables down to the ground meat and lard—are produced on her farm. But in praising Mrs. Hill's pasties, one runs up against the question of authenticity.

In the first place, can a Finn prepare proper Cornish pasties? One local Cornishman who ran a pasty contest disqualified his own wife because of her Finnish blood. This seems indefensible to me on many grounds and even smacks, in a genteel way, of the same anti-Finnish prejudice that has made "Finlander" a term of opprobrium in the Upper Peninsula. As with all traditional recipes, the pasty is a battleground of fiercely disputed culinary theories. Among themselves, the Cornish argue whether the dough should have suet or lard as a shortening, whether the filling should contain rutabaga, whether it is necessary to include pork in the chopped meat, and how coarsely or finely to chop that meat. Some folks pull the crust up from both sides and crimp it together at the top; others pull it over from one side. Some layer the ingredients; others mix them. The pasty controversy recently erupted in the pages of the *Upper Peninsula Sunday Times.* Steamy letters were written to the editor. One liberal Cornishman from Wyandotte, Michigan, a suburb of distant Detroit, plumped for pasty diversity and lamented the disappearance of Cornish culture. "The Cornish-American," he wrote, "has abandoned his folkways with unseemly haste. The only thing that survives in America of Cornish heritage is the pasty, that triumph of the Cornish culinary art, although even here much has been lost."

Perhaps. Nevertheless, the pasty has entered the mainstream of one American region, preserving something of the flavor of Cornwall even when adapted by Finnish hands. It is not clear, however, how much longer the Upper Peninsula pasty can hold its own against the recent, aggressive inroads of the fast food chains that bestride the highway into Marquette from the airport, but for the moment, to paraphrase a Cornish adage, the Devil seems to have kept out of the Upper Peninsula, "for fear of being made into a pasty."

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

### Bertha Hill's Pasties

3 cups unbleached all-purpose flour
Salt
⅔ cup lard
½ cup suet, diced
1 medium onion, peeled and diced
3 medium potatoes, peeled and diced
3 carrots, peeled and diced
¾ lb. beef chuck, coarsely chopped
¼ lb. pork loin, coarsely chopped
Pepper
Butter

1. Sift flour together with 1½ teaspoons salt.
2. Cut lard and suet into flour-salt mixture with a pastry blender until well incorporated, so that dough has the texture of coarse meal.
3. Stir in just enough cold water (a little more than ½ cup) so that dough will pull together into a mass. Let rest for an hour, covered.
4. Preheat oven to 425 degrees.
5. Mix together the vegetables and meats to make the filling. Season to taste with salt and pepper. Moisten with ½ cup cold water.
6. Take one-fourth of the dough and roll it out on a lightly floured surface to a circle 9 to 10 inches in diameter. Trim the edges using an inverted plate as a template.
7. Fill the circle with a mound of one-quarter of the filling. Dot the filling with butter. Place the filling on one side of the dough and shape into a mound that extends across one semicircle.
8. Pull the uncovered semicircle of dough over the filling and press it down against the opposite edge. Fold the crimped edge of the dough over on itself and press closed with the fingers. The pasty should look like a bulging half moon.
9. Continue in this manner until you have four large pasties.
10. Bake on a greased cookie sheet. After ten minutes, reduce heat to 375 and continue baking another 50 minutes or until done. The pasties are cooked when a fork will press easily through the crust and into the potato pieces inside.

Yield: Four pasties

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The itinerary includes London, Southampton, Dover, Edinburgh, the Shetland Islands, Loch Ewe, Galway, Holyhead, and Guernsey, with land excursions to Canterbury, Hadrian's Wall, Holy Cross, and spectacular natural settings.

Thomas D. Nicholson, director of the American Museum and astronomer, and six other scholars will introduce travelers to the archeological, historical, and natural treasures along the route.

The 80th-anniversary competition also will award seventeen cash prizes totaling $3,500. The winning entries will be published in the July issue of *Natural History* and exhibited at the American Museum of Natural History.

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Competitors may submit up to five entries in the competition.

The deadline is April 1, 1980. Please put your name and address on every entry and include a stamped, self-addressed envelope—since we want to return your pictures to you.

And good luck!

## THE RULES

1. The competition is open to everyone except employees of the American Museum and their kin.
2. Competitors may submit up to five previously unpublished entries (a sequence is considered a single entry).
3. The Museum acquires the right to publish, exhibit, and use for promotion the winning photographs. The Museum assumes no responsibility for other entries.
4. Entries may be transparencies or prints, either color or black and white, up to 8 by 10 inches. Each must bear the photographer's name and address.
5. Enclose a self-addressed, stamped envelope for the return of entries.
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*Robert G. Goelet, President*
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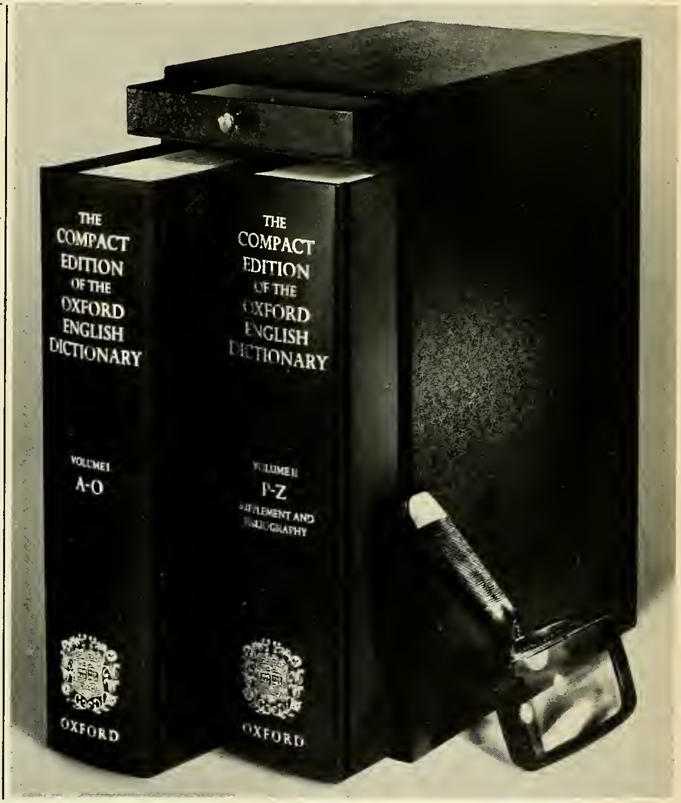
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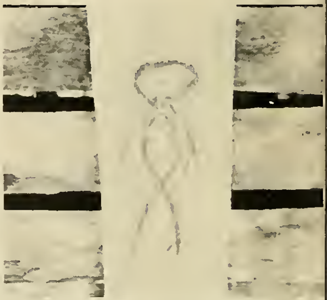
# Authors

**Mark Owens** was teaching at the University of Georgia when he met and married one of his students. After their marriage, Mark, who had a research background in glacial geology, and **Delia Owens** decided to go to Africa in search of a suitable research project. Their first choice was the teeming animal life of the Okavango Swamps in Botswana, but unusual rains made the area inaccessible. So they ventured into what seemed the next best choice: the Kalahari Desert. With a more than slightly used Land Rover, which cost them fifty dollars of their own precious funds, they crossed 125 miles of sand track and discovered a population of brown hyenas in the Deception Valley of the Central Kalahari Game Reserve. That was in 1974, and they have been studying hyena behavior and ecology ever since. Their isolation and experiences with the Land Rover have made them keenly interested in aviation.



**Edmund Carpenter** teaches anthropology at the New School for Social Research and communications at New York University. His accompanying portrait was painted by a Biami of Papua who saw him as a pale ancestor and rendered his likeness accordingly. An authority on the art and culture of the Arctic, but with a wide-ranging interest in other regions as well, Carpenter has lived and worked among Eskimo and Indian societies for many years. He is the author of *Eskimo Realities; Oh, What a Blow That Phantom Gave Me!* and several other books. His last article for *Natural History*, in May 1978, was "Silent Music and Invisible Art."

**Robert L. Smith** confesses he was "quite likely contemplating the biological and cultural consequences of feminist demands" when he first observed an egg-laden male water bug and instantly chose it as the subject for his doctoral dissertation in zoology from Arizona State University. He has subsequently traveled in Argentina, Mexico, and the United States to study these creatures and their paternal brooding behavior. As assistant professor of entomology at the University of Arizona, Smith has expanded his interest to include the behavior and ecology of urban insects but has been unable to shake his fascination with giant water bugs. He expects to continue to study them "for the duration."

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"I have been intrigued by the skin-shedding behavior of snakes since I was about nine," writes **Leonard G. Appleby**. "I now study snakes almost exclusively and would describe myself as a compulsive ophiologist." A native of Surrey, England, where he makes his home in the village of Surbiton, he has studied the snakes of Great Britain for forty years. In addition to his continuing work on ecdysis and thermoregulation, he is investigating the ritualistic combat displays of male snakes. Appleby is something of a sculptor, using soft metals or wood as his medium. The subjects, of course, are snakes. He also reports that he enjoys "writing humorous prose in an inane vein, and nonsense verse that's even worse." Some of the former has been published.

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# Turtles and the Revolution

General Anastasio Somoza-Debayle was not known for being a friend of the green turtle. His reputation had more to do with the way he ruled Nicaragua. But in 1977, even though he was reported to have an economic interest in the country's turtle business, he banned commercial-export turtling and closed the several processing plants operating in the country. His action was at least partly due to the urging of Bernard Nietschmann ("When the Turtle Collapses, the World Ends," June/July 1974), who flew to Nicaragua at Somoza's request in 1975 to talk about the plight of the fast-disappearing turtles.

In July of 1979, Somoza was deposed (he is now living in Paraguay) and Sandinista revolutionaries formed a new government. The turtles were not, of course, central to the revolution, and their fate under the new government was unclear until last fall, when a government representative announced that Nicaragua, although it was in financial trouble, would try to establish a marine sanctuary for the turtles if economic and technical assistance were forthcoming from the international community.

*"Postscripts" is a collection of reports on what's new with old* Natural History *articles.*

Butchering green turtles on beach, Nicaragua, 1971

Bernard Nietschmann

Nietschmann, who was at the conference where the announcement was made, thinks the aid will come. If it does, it will mean that the last large population of green sea turtles in the western Caribbean will be protected where it breeds, on the Tortuguero nesting beach in Costa Rica (made a national park in 1976), and in its feeding area, the rich marine pastures of sea grass off the eastern coast of Nicaragua.

But the turtles were only half of Nietschmann's story. He had become deeply involved with the Miskito Indians, who traditionally depended on the turtle for food. In the 1960s, when the first turtle-processing plants were set up in Nicaragua, the Miskito began their entry into a cash economy, hunting the turtles to sell. The turtles would have eventually disappeared if this increased hunting pressure had kept up, but stopping commercial turtling left the Miskito stranded partway through a cultural change. What provision a marine sanctuary would make for them, or for subsistence turtling, is not known, but their reaction to the 1977 closing of the plants was clear. As Nietschmann reports in his book *Caribbean Edge* (Bobbs-Merrill, 1979), the Miskito he was closest to wrote him in 1977, saying, "This is my word to you. The government put the turtle on control. It was one thing that you the one that do it. All your friends give you Hell. You get lots of cursing. Was sad."

*Please turn to page 12*

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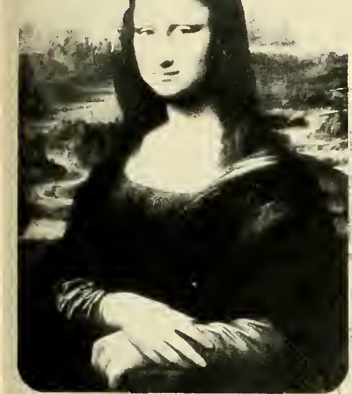

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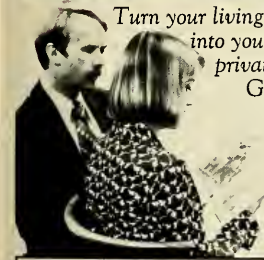

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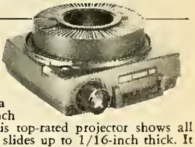

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## Feverish Lizards, and Crayfish, and Scorpions

Running a fever was once thought to be the prerogative of warmblooded creatures, whose internal temperatures are independent of the weather. But, as Matthew Kluger reported in "The Importance of Being Feverish" (January 1976), lizards can also develop fevers, even though there is no question that they are coldblooded. They raise their temperatures by moving into the sun or, in the case of Kluger's experiments, under a sun lamp. And it seems to do them some good. Sick lizards kept in cages at feverish temperatures fare much better than their counterparts in normal and cool environments.

Now, fever has spread to invertebrates. Recent studies have shown that crayfish and scorpions can develop fevers. Crayfish injected with bacteria and scorpions injected with prostaglandins swam and scuttled to hot areas. (Prostaglandins are hormones thought to be instrumental in the development of a fever.)

Evidence is also mounting that moderate fevers have their benefits, which might explain why the fever process is so widespread. Leukocytes, white blood cells that are active in fighting bacterial infections, are more mobile at febrile temperatures. And fevers reduce the amount of iron available to bacteria. That reduction, combined with high temperatures, has been shown to inhibit bacterial growth.

## Schistosomiasis, a Change in Strategy

In 1960, the word coming out of China was that schistosomiasis (snail fever) was under complete control and eradication was imminent. Almost twenty years later, in September of 1979, the *New York Times* offered the news that China had undertaken a vast, ambitious program to wipe out schistosomiasis by 1985.

Kenneth Warren, director of Health Sciences at the Rockefeller Foundation, was not surprised. Several years ago, in "Precarious Odyssey of an Unconquered Parasite" (May 1974), he set forth some of the reasons schistosomiasis, which affects 200 million people, resists efforts to eliminate it. Warren believes that such efforts, now being pursued in China, Brazil, and Egypt, are futile with current tools. He recently backed up his contention by designing, at Kenya's request, a program for control, not eradication, of schistosomiasis.

The difficulty with attempts at eradication is that they require striking the parasitic worm that causes schistosomiasis at every stage of its life. The worm, at different stages, lives in snails, humans, and in bodies of fresh water while it waits to infect one of its hosts. Eradication programs must include improving sanitation and protecting water supplies (eggs are excreted by infected human beings), killing snails, and killing the worms in human beings through medical treatment. So far there is no vaccine. Antischistosomal drugs are known for their toxicity to humans. And no molluscicides (snail-killing chemicals) have long-term, residual action. The problems are formidable even if one doesn't question the wisdom of killing large numbers of snails with chemicals.

Warren sees a way out of these difficulties in a significant characteristic of schistosomiasis: infection is not the same as disease. The worms do not multiply inside the human body; they produce eggs that are excreted. And individuals infected by a few worms may show no ill effects. Heavy infections, however, can cause a variety of disease symptoms and can sometimes be fatal. Another important characteristic of schistosomiasis is that schoolchildren have the highest incidence of infection.

Warren's recommended program, to cost $10 million over six years, would involve testing children ages five to nineteen in areas where schistosomiasis is endemic. Newly refined diagnostic procedures that allow quick tests in the field would be used, and only children with a certain level of infection would then be treated with drugs. Warren has devised a one-shot medication program that reduces the toxicity of the treatment by reducing the doses. He believes the program is a simple, economical alternative to eradication programs and that it will be effective in doing what can and should be done: treating the disease of schistosomiasis, not eliminating infection. The Kenyan government has not yet decided whether to go ahead with the program.

*James Gorman*

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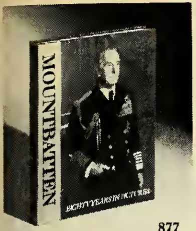

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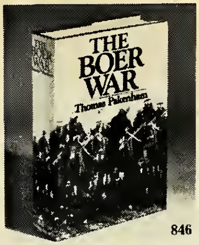

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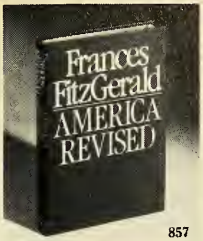

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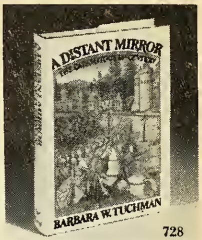

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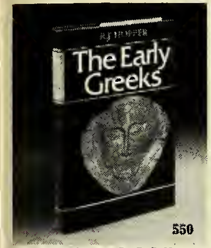

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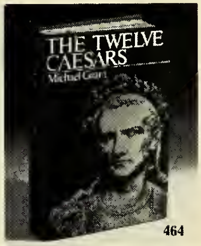

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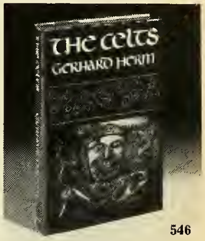

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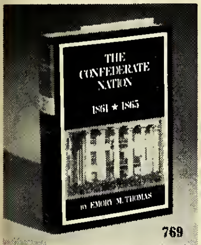

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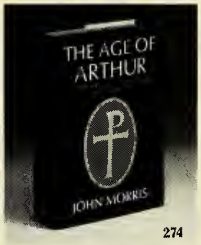

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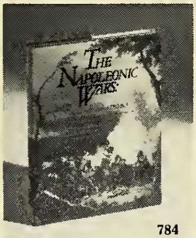

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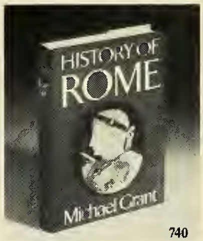

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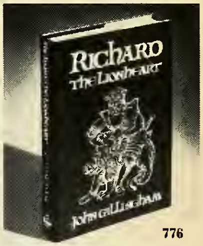

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# New England Returns to Wood

*Faced with soaring energy costs and a disquieting dependence on foreign oil, this region has begun shifting to a former source of heat and power*

### by Colin High

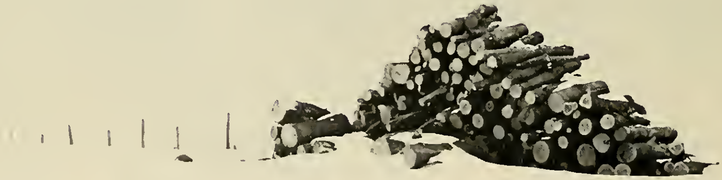
We are witnessing the rebirth of the use of New England forests, a trend that is growing so fast it is not yet reflected in most government statistics. Just as the bicentennial revived interest in the early history of the area, so rising fuel prices and supply problems have produced a renewed interest in the fuels of earlier times.

Although there are no statistics for those times, we are fairly certain that wood provided close to 100 percent of the fuel needs of the Pilgrim Fathers, as it undoubtedly also did for the American Indians before them. Wood continued to be the primary fuel for New Englanders until the latter part of the nineteenth century. It was used for heating homes, for cooking, and to produce the hot water needed on farms and for cottage industries. It provided charcoal for iron making and steam for the early steam engines, railroads, steamboats, and steam-powered sawmills. By 1850 there were thirty-six steam-powered sawmills fired by wood in Maine alone.

Along with water and wind, wood was the energy source for the American industrial revolution. In the second half of the nineteenth century, coal became increasingly important as an industrial fuel in the United States, although its use began relatively much later than in Europe, where the wood resource had been depleted much earlier. Not until the early 1870s did coal surpass the solar fuels—wood, water, and wind—as the primary industrial fuel.

Until well into the twentieth century, wood remained the major home heating fuel in New England, finally declining only in the face of the abundance of cheap and convenient oil, gas, and electricity. By the time of the Arab oil embargo of 1973, the use of wood for home heating had declined to such a degree that even in Vermont, one of the most rural and wooded states in the nation, less than one percent of all homes used wood as the primary heat source.

The situation in the rest of rural New England was much the same, and in the urban areas, wood heating was relegated to the occasional use of the fireplace. Instead of relying on home-grown fuels, New England became dependent on oil, mainly imported from foreign sources. With the highest energy costs in the nation and the greatest dependence on foreign oil, however,



B.A. King

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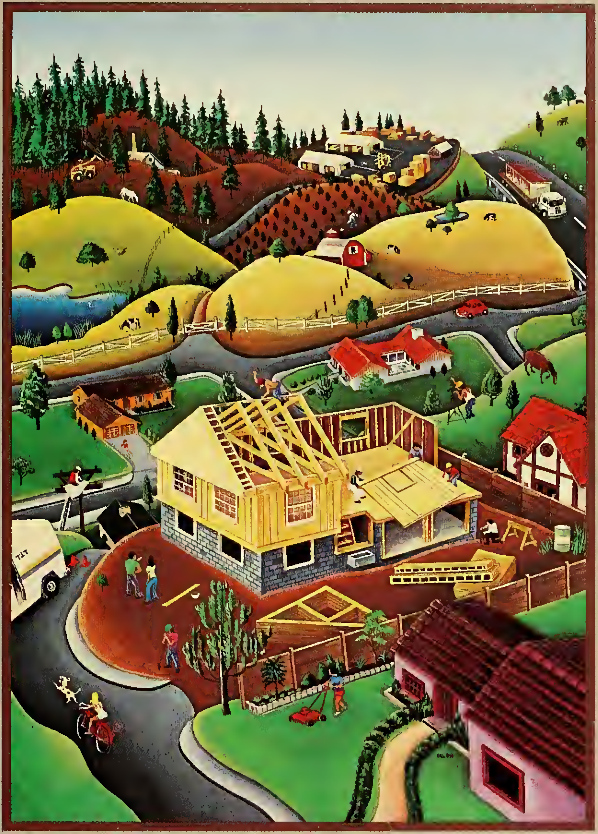

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George A. Robinson

*The number of New Englanders heating their homes primarily with wood has increased from less than one percent to about 20 percent since the Arab oil embargo in 1973. Many homeowners now cut their own wood.*

the New England region is now looking to indigenous energy sources, especially renewable resources, to meet its future energy needs.

Change has begun and is taking two forms—conservation and a shift to wood. As a result, oil consumption may be 20 to 30 percent lower this winter than in the past. Although conservation is becoming a national phenomenon, the shift to wood for home and industrial heating is so far being led by New England. From less than one percent of homes heated primarily with wood prior to 1973, we now find 20 percent or more of homes in northern New England heated primarily with wood and more than 50 percent partly heated with wood. There are now enough fireplaces and stoves being installed to drive those numbers up very rapidly if home heating oil becomes scarce or much more expensive.

During the fall of 1979, the traditionally quiet, steady business of cutting wood for winter suddenly became feverish, with prices shooting up and waiting lists for deliveries of wood and chain saws. Homeowners discovered that the price differential between wood and oil was so large that even with the $300 to $500 or more spent on a stove, they could save hundreds of dollars in the first heating season.

If you are strong, like to be out in the woods, and have access to a pickup or trailer, you can go out and cut the wood yourself in rural areas. Even those who do not own woodlots frequently find neighbors who will allow dead and poor quality wood to be cut. Public forests also have opportunities for firewood cutters, and many large landowners and timber and paper companies permit local people to cut firewood free or at nominal cost. Perhaps half of all the wood now burned in New England homes is cut by the homeowner. Wood-cutting and wood-splitting parties are becoming popular as friends and neighbors turn to mutual aid instead of calling the oil company. Local businesses that sell wood stoves and chain saws, build chimneys, or rent hydraulic wood-splitters have been doing a roaring trade. On the other hand, local oil distributors have been having a hard time and some smaller, marginal companies may fail.

The resurgence of wood burning, however, has not been without its problems. Few people under forty or fifty years of age have had much direct experience of wood burning, and recent migrants from the cities, who often embrace wood heating with a religious fervor, have had no experience at all. Not surprisingly, there has been a spate of fires caused by ignorance and poor equipment or poor installation.

Burning wood is an art. You need to know your wood: the species, the condition, and the moisture content. A fast-burning, light softwood, such as pine, is fine for kindling, but to hold a good fire, you need oak, maple, or hickory. Apple holds a fire well all night and has a better aroma than anything out of a can or bottle. White birch looks beautiful in the grate of an open fire, but the serious stove user is not impressed by its heat value and tends to regard it as a city dweller's wood.

The experienced wood burner will use nothing but hardwood, except for kindling. Hardwoods generally have a much higher heating value per cord than softwoods. Perhaps just as important, they do not produce as much creosote or as many sparks as pine, spruce, or fir. Creosote is a big problem when heating a house all winter, especially a house with a modern, high-efficiency, "airtight" stove. As the hot gases driven off in the first stages of burning condense in the stovepipe and chimney, they build up and can catch fire. Burning the stove hotter with a good draft reduces creosote but makes it difficult to keep a fire going all night. Modern airtight wood stoves, so called because they have precise air regula-

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tors or thermostats, produce an even heat but they do not solve the creosote problem. The prudent stove owner checks the chimney regularly for creosote buildup and sweeps it often.

If there is an art to burning wood, there is an even greater art to cutting, splitting, and drying it. A few general principles will guide the neophyte, but only experience will make you an expert. Never cut wood shorter than you need for your stove (better buy a stove that takes long wood). Cut your wood in the fall: that is when the sap is lowest. Split it in the winter: frozen wood splits the most easily. Cut at least a year before you need to burn the wood: dry wood burns better than green wood. Wood cutting, splitting, drying, and burning are best practiced in time to the rhythm of the seasons. But there is an art to the splitting of wood, to the handling of mauls, wedges, and sledgehammers, to knowing which wood splits easily (straight ash or birch) and which will need a lot of work with wedges and hammers (elm and locust are notorious). My first wood-heated winter in New England cost me three splitting-maul handles for lack of experience in these arts.

Since it presents so many problems, why are so many people changing to heating with wood? For some it is a case of economic necessity. For the unemployed and those on low incomes who can cut their own wood, the savings, compared with oil, gas, or electricity, may amount to hundreds of dollars a year and make the long, cold New England winters bearable. But for those with little time to spare, cutting their own wood provides only a marginal return. And for people who buy their wood cut, split, and delivered to the home, costs range from about $75 to $120 per cord. At the top of this price range, wood is more expensive than oil at present prices, even if the wood is dry. When wood is burned green (moisture content 45 to 50 percent by weight), the heating value is only about 4,200 BTUs per pound compared to an average of 8,500 BTUs per pound for bone-dry wood. This means that someone burning green wood purchased for $75 per cord is probably not saving any money compared with buying home heating oil.

Nevertheless, many people are buying wood at $100 or more per cord. Clearly, something other than saving money must be motivating them. Throwing a log on a blazing fire obviously provides some satisfaction that

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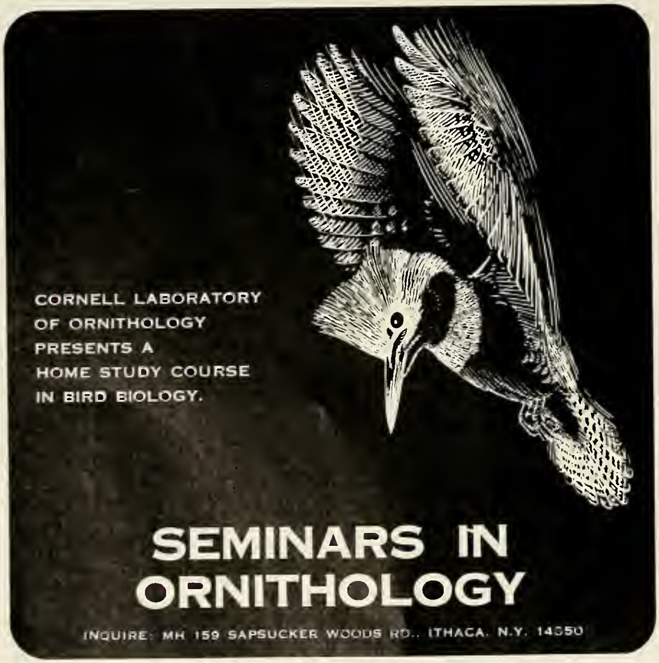

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you do not get from hearing your furnace turn itself on. In these troubling times, that may be worth paying for. Having an alternative emergency fuel available also engenders a sense of security. There has long been a New England saying that wood warms you twice: once when you cut it and once when you burn it. Some people now add a third time: knowing you are not dependent on OPEC.

Although residential users are leading the shift from oil and electricity to wood, industrial users are also changing over. If homeowners are motivated by a mixture of economic and noneconomic reasons, industries have generally made the choice for economic reasons alone. Many of the industrial users who have switched from oil are in wood-products industries and burn the waste wood, sawdust, and bark they previously considered of little or no value. Starting with free or very low-cost fuel from waste, they have chalked up substantial savings in the first few years of operations.

There are 150 wood-burning industries in New England, from small sawmills and furniture factories to giant pulp and paper mills, which burn bark, wood, and wood-derived black liquor from the pulping process to generate steam and electric power. Some of these industries are powered almost entirely by wood, and some, like the Scott Paper Company's Somerset Mill in Maine, occasionally sell power to the electric grid. The Burlington Electric Department in Vermont retrofitted a coal-burning power plant to burn wood and now produces 7 megawatts of electric power for the city of Burlington. Although most of the industrial wood boilers depend primarily on low-cost wood wastes, the Burlington electric plant and a much smaller steam unit serving a hospital in Waterbury, Vermont, are examples of plants that burn wood harvested specifically for energy by whole-tree harvesting.

Unlike regular logging techniques, which normally use only the bole of the tree, whole-tree harvesting removes all the above-ground parts of the tree, which are then converted by machine into small chips. The chips are transported in large semitrailer vans, with twenty-ton loads, to an industrial boiler for burning. Whole-tree chipping has been used in New England and elsewhere to provide fiber for pulp mills and is expected to become the primary method for harvesting wood fuel for industrial use.

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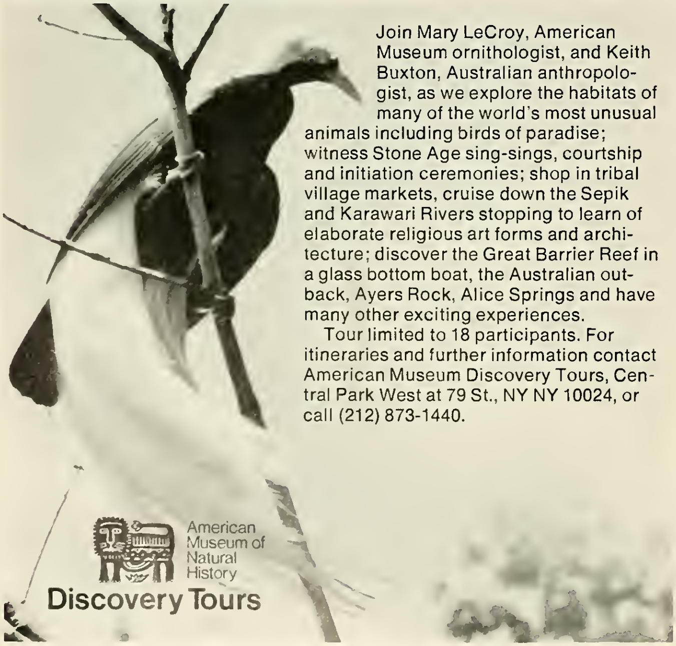

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On such a scale, wood can be harvested and delivered up to fifty or more miles away at a cost of about $15 to $20 per ton ($36 to $48 per cord). At that price wood becomes competitive with oil even allowing for the increased capital investment and operation costs associated with wood burning. In view of this situation, the federal Department of Energy, state governments, and federally funded organizations, such as the New England Regional Commission and the Northeast Solar Energy Center, are encouraging industry to change from oil to wood in areas where wood is available.

In some areas it is possible that wood for energy may develop into the resource's major use. In northern Vermont, for example, just one proposed 50 megawatt, wood-fired power plant will, if built, double the wood harvest in the northern part of the state. If the domestic fuel wood market is added to this, wood used for energy may become an important factor in changing the forests of New England.

Proponents of wood energy can point to several important benefits that the growth of a large wood energy market could have in the New England forests. Wood as fuel could present the opportunity to market the large quantities of rough, rotten, and otherwise unmarketable trees that abound in New England's forests. From a production point of view, the present poor condition of the forests is the result of a long history of overexploitation of the high-quality trees, followed by a lack of forest management to regenerate high-productivity stands.

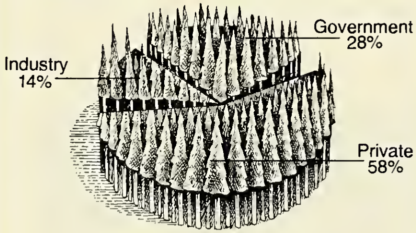
The lack of management occurred, in part, because it was difficult to make a decent return on the investment while large stands of old growth timber were available in the west and higher rates of growth could be obtained in the south. In addition, the land-ownership patterns of southern and central New England, which has many relatively small owners whose primary income comes from sources other than the land and whose reasons for holding the land are largely unrelated to forest production, have made good forest management more difficult. A wood energy market for the poor-quality material could provide the economic incentive to improve the stands by selective thinning and other management practices. Many foresters see the biggest benefit of wood energy as improvements to the timber stands, a policy they have long advocated but one that few landowners

A report on the great American forest.

# Good forest management means growing more trees. Not sharing shortages.

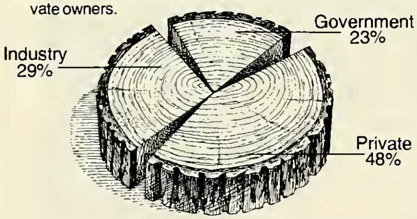
Who owns America's commercial forests?

Commercial forest acreage owned by the forest industry, government, and non-industrial private owners.



And how much do they produce?

Annual harvest from commercial forests owned by the forest industry, government, and non-industrial private owners.



Source: U.S. Forest Service

It's no accident that the most productive forests in America are those owned and managed by the forest industry.

Although they make up only 14% of the commercial forestland, they provide 29% of the annual timber harvest.

This is because the industry has learned that it's not only possible to grow more trees faster, but also imperative.

It's a race against time: Every year Americans need more lumber and plywood to build homes. More furniture to make them liveable. More paper and pulp to print the books and periodicals that educate, enlighten and entertain. More packaging and containers for thousands of essentials, from milk to machinery.

The sobering fact is that within 50 years U.S. demand for wood and paper products is expected to double.

Yet not all the nation's commercial forests are working equally hard to get ready.

## What is a commercial forest?

*Commercial forest,* as defined by the U.S. Forest Service, is *all* forestland — whether owned by individuals, government or the forest industry — that is capable of, and potentially available for, growing repeated crops of trees for harvest. It includes land in National Forests but not in National Parks or Wilderness areas.

On all commercial forestland, tree growth per acre averages only 61% of potential, which is not good enough. The greatest room for improvement, however, is in National Forests, where trees now grow at only 48% of potential.

Yet as the industry has shown, the growth cycle can be speeded by applying such techniques as: encouraging natural regrowth, planting superior seeds and seedlings, fertilizing, thinning and protecting trees from disease, insects and fire.

## How soon can we start growing more trees?

Since we clearly have the know-how to grow more and higher-quality trees, how soon can this nation get on with the job of increasing productivity on *all* commercial forestlands?

The first step is to understand the problem. If you'd like to learn more about the importance of America's forests and the challenges they face, send for a free booklet, "The Great American Forest." Write American Forest Institute, P.O. Box 873, Springfield, VA 22150.

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could afford. Other benefits would be realized by loggers using whole-tree harvesting machines that increase productivity and reduce the job hazards associated with traditional logging.

Furthermore, whole-tree chipping reduces or eliminates the slash left after logging, which many landowners and recreational forest users find so objectionable. More open forests, with larger trees and a mosaic of cuttings, which could result from a well-managed, selective whole-tree harvest, would provide pleasant opportunities for recreational use and a diversity of habitats for wildlife.

Despite the advantages offered by large-scale, whole-tree, mechanized harvesting, there is no evidence that such a forest-management program will be adopted. At present, there are no laws or economic incentives to insure that it will take place. On the contrary, there may be short-term economic incentives that make it hard to practice good management. We know that wood fuel is, and probably will remain, the lowest-value wood product of the forests and that wood is competing closely with other energy sources. Loggers and landowners are therefore under constant pressure to keep costs down. To do so, loggers will have to make large investments in feller bunchers, skidders, and chippers to deliver fuel wood at a competitive price. A typical operation will need $500,000 for equipment, and loggers will have to be highly cost conscious and productive to make a return on the investment.

Large machines are undoubtedly more productive in clear cuts than in selective operations and that could lead to a substantial increase in clear-cutting. Clear-cutting may be right in some circumstances, but it has a far greater impact on the ecosystem than other cutting practices. All of the results traditionally associated with logging—increased runoff, soil erosion, water-quality problems, stream-temperature increase, nutrient removal, fish and wildlife disturbance, and adverse aesthetic and recreational effects—are more severe and difficult and expensive to manage in clear cuts.

There is one further problem with which we have relatively little experience, namely, the effect of whole-tree harvesting on soil nutrients and the long-term productivity of the forest. Although in most respects whole-tree harvesting produces the same results as traditional logging, it removes from the forest a much higher proportion of the biomass. The removal of small branches and leaves in whole-tree harvesting may be especially important because the leaves and twigs contain a disproportionately high concentration of plant nutrients—nutrients that might otherwise return to the soil in traditional harvesting. Moreover, we know that the decaying wood on the forest floor provides important sites for nitrogen fixation. To the extent that whole-tree harvesting reduces the amount of wood left to decay on the forest floor, it will reduce the rate of nitrogen return to the forest soil.

Although the impact on the nutrient budget of the forest may be quite small and may not affect forest productivity in the first rotation after whole-tree harvesting, there is a strong possibility that productivity will be affected after successive harvests employing whole-tree methods. If those methods were to be used only for the first harvest, the problem would be of less concern. But there is no reason to suppose that loggers will want to return to traditional methods in future harvests once they

B.A. King

*Commercially cut firewood ready for home delivery may not save the homeowner money at present. But as the costs of heating oil and electric rates continue to rise, wood is bound to become more and more economically attractive.*

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**OVERCOMING YOUR PSYCHOLOGICAL RESISTANCE TO SEAT BELTS MAY BE THE KEY.**

The facts are startling. Experts estimate that about half of all automobile occupant fatalities last year might have been avoided if the people had been wearing seat belts. That's because injuries occur when the car stops abruptly and the occupants are thrown against the car's interior. Belts prevent this.

Many people say they know the facts, but they still don't wear belts. Their reasons range all over the lot: seat belts are troublesome to put on, they are uncomfortable, or they wrinkle your clothes. Some people even think getting hurt or killed in a car accident is a question of fate; and therefore, seat belts don't matter.

If you're one of those people who don't use belts for one reason or another, please think carefully about your motivations. Are your objections to seat belts based on the facts or on rationalizations?

**Here are a few of the common rationalizations.** Many people say they are afraid of being trapped in a car by a seat belt. In fact, in the vast majority of cases, seat belts protect passengers from severe injuries, allowing them to escape more quickly. Another popular rationalization: you'll be saved by being thrown clear of the car. Here again, research has proved that to be untrue—you are almost always safer inside the car.

Some people use seat belts for highway driving, but rationalize it's not worth the trouble to buckle up for short trips. The numbers tell a different story: 80% of all automobile accidents causing injury or death involve cars traveling under 40 miles per hour. And three quarters of all collisions happen less than 25 miles from the driver's home.

**When you're the driver, you have the psychological authority to convince all of the passengers that they should wear seat belts.** It has been shown that in a car, the driver is considered to be an authority figure. A simple reminder from you may help save someone's life. And please remember children can be severely injured in automobile accidents, too. Make sure Child Restraint Systems are used for children who aren't old enough to use regular seat belts.

Because so many people still don't use their seat belts, the government has directed that some form of passive restraint—one that doesn't require any action by the occupant—be built into every car by the 1984 model year. GM is offering one such restraint—a new type of automatic belt—as an option on the 1980 Chevette to gain insight into its public acceptance.

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*The Outlaw, a front view.*

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have discovered the economic advantages of whole-tree methods.

Indeed, the improving technology for the production of composite wood products suggests that the market for wood chips to be used in the manufacture of wood products may also increase in the future. It has been suggested that "energy plantations" of fast-growing trees, harvested on short rotations with whole-tree harvesting methods, would be the way to produce wood fuel quickly and cheaply. If put into practice, this would be more like agricultural crop production than forestry as we know it and might cause soil erosion and water-quality problems that would parallel the seriousness of those in agriculture. But with or without energy plantations, whole-tree harvesting is here to stay.

Just as increased harvesting of wood for energy will pose difficult environmental management problems in the forest, increased wood burning in the home and industrial plants will give rise to air-pollution problems. Because wood is a renewable resource and wood smoke brings back pleasant memories of evenings around the campfire, a popular misconception has grown up that wood burning is totally benign. The problems of wood as fuel may cause less alarm than the health risks associated with coal or nuclear fuels, but wood is certainly not without some hazards.

Wood burning produces a wide range of emission products, some of which can present a health threat. The emissions include particulates, nitrogen oxides, carbon monoxide, hydrocarbons, and sulfur dioxide. The sulfur emissions are very low when compared with those of coal and most oils, and that makes wood a preferred fuel where sulfur dioxide pollution is a problem. On the other hand, particulate emissions, particularly where no control equipment is used, are higher than those caused by oil, being comparable to emissions from coal burning.

Fortunately, particulate emissions are relatively easy to control in industrial boilers and the control technology is widely available. Particulate emissions from residential fireplaces, stoves, and furnaces, however, are not controlled and these emissions are a cause for concern where there is a heavy concentration of home wood users. Many small towns in valleys where temperature inversions occur on cold winter nights are already beginning to experience noticeable air-

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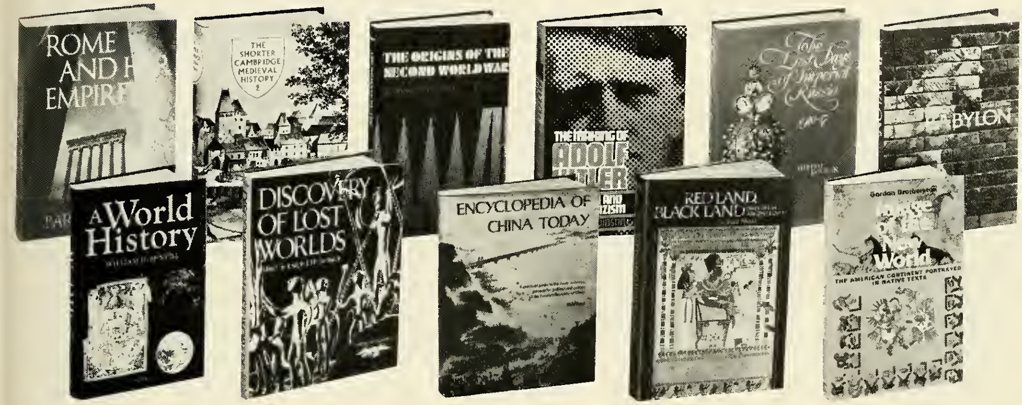
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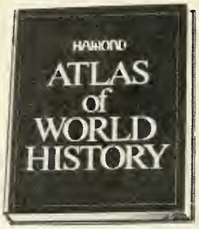

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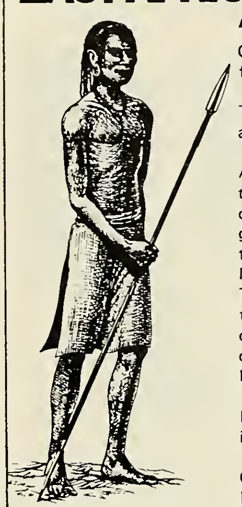

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As can be seen, the wood-energy market involves a number of tradeoffs. On one hand, if properly managed, it might provide a way in which the present poor-quality, low-productivity forest could produce more high-value timber and fiber while maintaining or improving environmental quality. Such management would need to forego short-term profit for longer-term profit. On the other hand, to supply the energy market at the lowest possible price, loggers and landowners might opt for maximum productivity in the short term, which would probably lead to increased clear-cutting and negative effects on the forest ecosystem and downstream water quality.

The problems of management are better understood now than they once were and there is a will on the part of most parties to consider environmental issues and long-term productivity. Nevertheless, the history of the exploitation of New England's forests has largely been a story of maximizing short-term profit at the expense of long-term benefits. That may be changing but a mechanism for insuring management for longer-term benefits has not yet emerged.

Forests provide not only fuel but also materials that can play an important role in conserving energy in manufacturing processes. Wood products use less energy than industrial substitutes, such as plastics, steel, and aluminum. We may hope that in the rush to get energy out of the woods to satisfy an appetite developed on an abundance of cheap oil we do not forget the multitude of other benefits that well-managed forests can provide.

*Colin High is research associate professor in the Resource Policy Center of the Thayer School of Engineering at Dartmouth College.*

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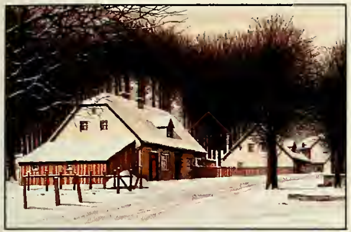

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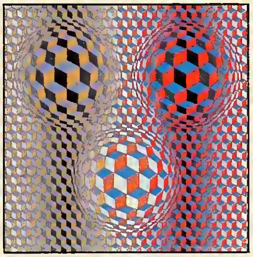

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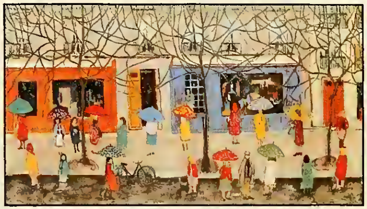

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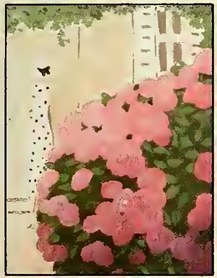

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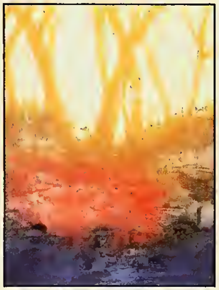

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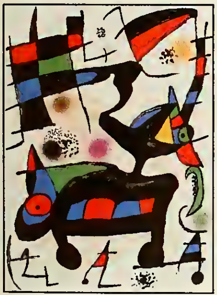

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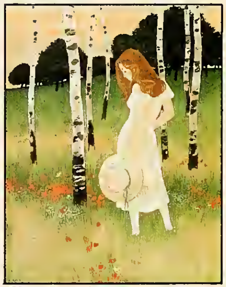

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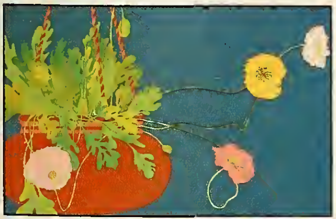

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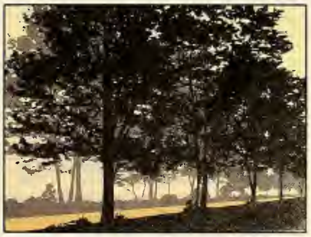

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# In the Midst of Life . . .

*What would an algal mat think of the fiery finale of our solar system?*

Great storytellers often insert bits of humor to relieve the pace of intense drama. Thus, the gravediggers of *Hamlet* or the courtiers Ping, Pong, and Pang of Puccini's *Turandot* prepare us for torture and death to follow. Sometimes, however, episodes that now inspire smiles or laughter were not so designed; the passage of time has obliterated their context and invested the words themselves with an unintended humor in our altered world. Such a passage appears in the midst of geology's most celebrated and serious document—Charles Lyell's *Principles of Geology*, published in three volumes between 1830 and 1833. In it, Lyell argues that the great beasts of yore will return to grace our earth anew:

> Then might those genera of animals return, of which the memorials are preserved in the ancient rocks of our continents. The huge iguanodon might reappear in the woods, and the ichthyosaur in the sea, while the pterodactyl might flit again through the umbrageous groves of tree-ferns.

Lyell's choice of image is striking, but his argument is essential to the major theme of his great work. Lyell wrote the *Principles* to advance his concept of uniformity, his belief that the earth, after "settling down" from the effects of its initial formation, had stayed pretty much the same—no global catastrophes, no steady progress toward any higher state.

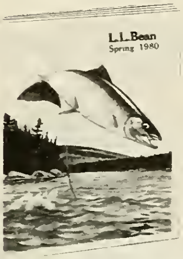
The extinction of dinosaurs seemed to pose a challenge to Lyell's uniformity. Had they not, after all, been replaced by superior mammals? And didn't this indicate that life's history had a direction? Lyell responded that the replacement of dinosaurs by mammals was part of a grand, recurring cycle—the "great year"—not a step up the ladder of perfection. Climates cycle and life matches climates. Thus, when the summer of the great year came round again, the coldblooded reptiles would reappear to rule once more.

And yet, for all the fervor of his uniformitarian conviction, Lyell did allow one rather important exception to his vision of an earth marching resolutely in place—the origin of *Homo sapiens* at the latest instant of geologic time. Our arrival, he argued, must be viewed as a discontinuity in the history of our planet: "To pretend that such a step, or rather leap, can be part of a regular series of changes in the animal world, is to strain analogy beyond all reasonable bounds."

To be sure, Lyell tried to soften the blow he had administered to his own system. He argued that the discontinuity reflected an event in the moral sphere alone—an addition to another realm, not a disruption of the continuing steady-state of the purely material world. The human body, after all, could not be viewed as a Rolls Royce among mammals:

> When it is said that the human race is of far higher dignity than were any preexisting beings on the earth, it is the intellectual and moral attributes only of our race, not the animal, which are considered; and it is by no means clear, that the organization of man is such as would confer a decided preeminence upon him, if, in place of his reasoning powers, he was merely provided with such instincts as are possessed by the lower animals.

Nonetheless, Lyell's argument is a



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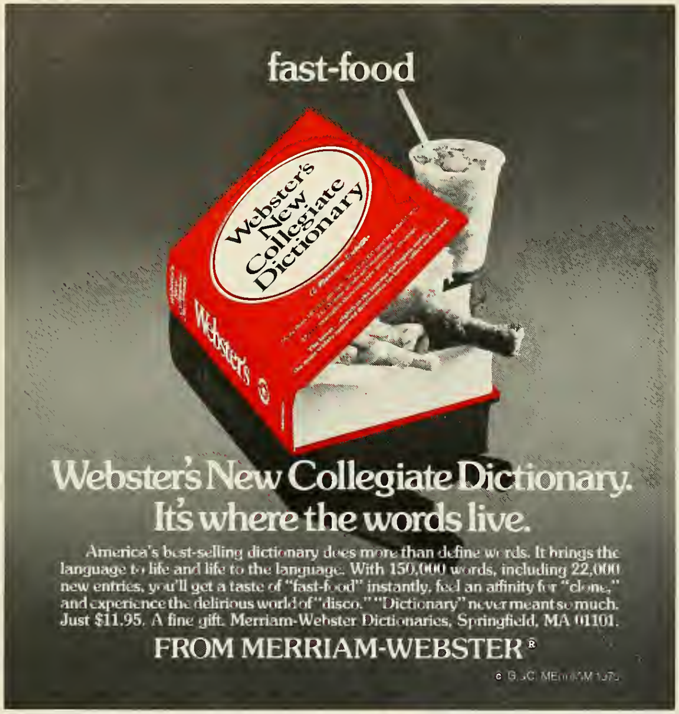

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premier example of an all too common tendency among natural historians—the erection of a picket fence around their own species. The fence sports a sign: So Far, but No Farther. Again and again, we encounter sweeping visions, encompassing everything from the primordial dust cloud to the chimpanzee. Then, at the very threshold of a comprehensive system, traditional pride and prejudice intervene to secure an exceptional status for one peculiar primate.

I discussed another example of the same failure in last month's column—Alfred Russel Wallace's argument for the special creation of human intelligence, the only imposition by divine power upon an organic world constructed entirely by natural selection. The specific form of the argument varies, but its intent is ever the same—to separate man from nature. Below its main sign, Lyell's fence proclaims, The Moral Order Begins Here; Wallace's reads, Natural Selection No Longer at Work.

Darwin, on the other hand, extended his revolution in thought consistently throughout the entire animal kingdom. Moreover, he explicitly advanced it into the most sensitive areas of human life. Evolution of the human body was upsetting enough, but at least it left the mind potentially inviolate. But Darwin went on. He wrote an entire book to assert that the most refined expressions of human emotion had an animal origin. And if feelings had evolved, could thoughts be far behind?

The picket fence around *Homo sapiens* rests on several supports, but the most important pillars embody claims for *preparation* and *transcendence*. Humans have not only transcended the ordinary forces of nature, but all that came before was, in some important sense, a preparation for our eventual appearance. Of these two arguments, I regard preparation as by far the more dubious and more expressive of embedded prejudices that we should strive to shed.

Transcendence, in modern guise, states that the history of our peculiar species has been directed by processes that had not operated before on earth. As I argued in my recent column on Lamarck (October 1979), cultural evolution is our primary innovation. It works by the transmission of skills, knowledge, and behavior through learning—a cultural inheritance of acquired characters. This nonbiological process operates in the rapid Lamarck-

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ian mode, while biological change must plod along by Darwinian steps, glacially slow in comparison. I do not regard this unleashing of Lamarckian processes as a transcendence in the usual sense of overcoming. Biological evolution is neither canceled nor outmaneuvered. It continues as before and it constrains patterns of culture, but it is too slow to have much impact on the frenetic pace of our changing civilizations.

Preparation, on the other hand, is hubris of a much deeper kind. Transcendence does not compel us to view 4 billion years of antecedent history as any foreshadowing of our special skills. We may be here by unpredictable good fortune and still embody something new and powerful. But preparation leads us to trace the germ of our later arrival into all previous ages of an immensely long and complicated history. For a species that has been on earth for about 1/100,000 of the planet's existence (50,000 of nearly 5 billion years), this is unwarranted self-inflation of the highest order.

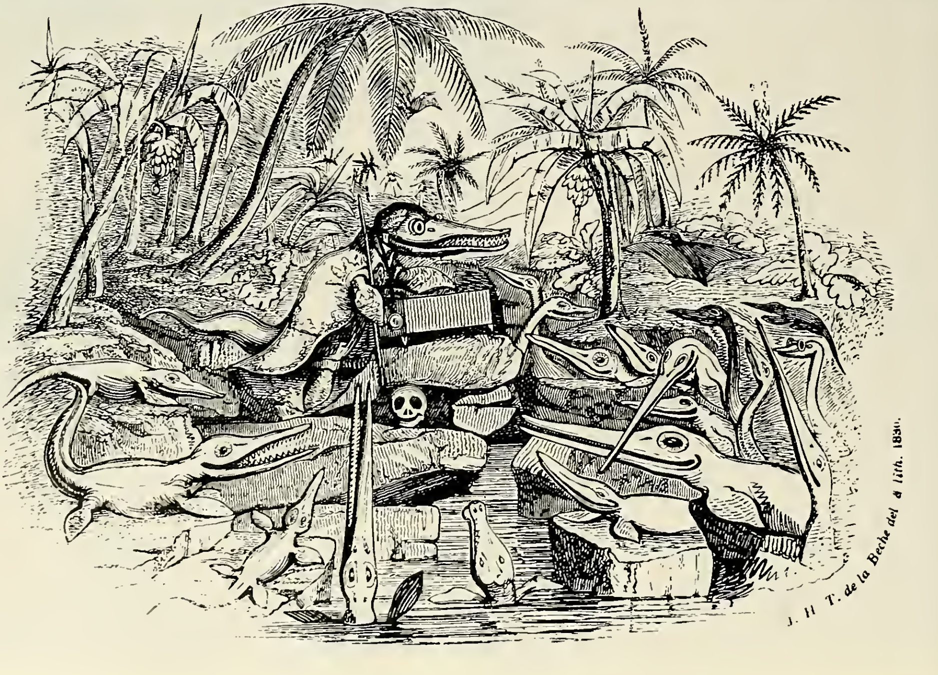
Lyell and Wallace both preached a form of preparation; virtually all builders of picket fences have done so. Lyell depicted an earth in steady-state waiting, indeed almost yearning, for the arrival of a conscious being that could understand and appreciate its sublime and uniform design. Wallace, who later turned to spiritualism, advanced the more common claim that physical evolution had occurred in order, ultimately, to link preexisting mind with a body capable of using it:

> We, who accept the existence of a spiritual world, can look upon the universe as a grand consistent whole adapted in all its parts to the development of spiritual beings capable of indefinite life and perfectibility. To us, the whole purpose, the only *raison d'être* of the world—with all its complexities of physical structure, with its grand geological progress, the slow evolution of the vegetable and animal kingdoms, and the ultimate appearance of man—was the development of the human spirit in association with the human body.

I think that all evolutionists would now reject Wallace's version of the argument for preparation—the foreordination of man in the literal sense. But can there be a legitimate and modern form of the general claim? I believe that such an argument can be constructed, and I also believe that it is the wrong way to view the history of life.

The modern version chucks foreordination in favor of predictability. It abandons the idea that the germ of *Homo sapiens* lay embedded in the primordial bacterium or that some spiritual force superintended organic evolution, waiting to infuse mind into the first body worthy of receiving it. Instead, it holds that the fully natural process of organic evolution follows certain paths because its primary agent, natural selection, constructs ever more successful designs that prevail in competition against earlier models. The pathways of improvement are rigidly limited by the nature of building materials and the earth's environment. There are only a few ways—perhaps only one—to construct a good flyer, swimmer, or runner. If we could go back to that primordial bacterium and start the process again, evolution would follow roughly the same path. Evolution is more like turning a ratchet than casting water on a broad and uniform slope. It proceeds in a kind of lockstep; each stage raises the process one step up, and each is a necessary prelude to the next.

Since life began in microscopic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*In Lyell's own day, a colleague drew this satirical cartoon of a future Professor Ichthyosaurus lecturing his students about a curious skull from a previous creation.*

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| Start Saving at Age | Put in Maximum of $1,500/Yr. | Start Saving at Age | Put in Maximum of $1,500/Yr. |
|---|---|---|---|
| 30 | $309,844.78 | 45 | $78,242.53 |
| 35 | $200,134.79 | 50 | $45,740.29 |
| 40 | $126,998.10 | 55 | $24,073.11 |

NOTE: In order to earn interest at this rate, deposits, including accrued interest, must not be withdrawn prior to maturity. Federal law and regulation prohibit the payment of an IRA Time Deposit (8% IRA) prior to maturity or before the depositor attains age 59½ (except in the case of death or disability), unless six months of the interest thereon is forfeited.

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chemistry and has now reached consciousness, the ratchet contains a long sequence of steps. These steps may not be ''preparations'' in the old sense of foreordination, but they are both predictable and necessary stages in an unsurprising sequence. In an important sense, they prepare the way for human evolution. We are here for a reason after all even though that reason lies in the mechanics of engineering rather than in the volition of a deity.

But if evolution proceeded as a lockstep, then the fossil record should display a pattern of gradual and sequential advance in organization. It does not, and I regard this failure as the most telling argument against an evolutionary ratchet. Life arose soon after the earth itself formed; it then plateaued for as long as 3 billion years—perhaps five-sixths of its total history. Throughout this vast period, life remained on the prokaryotic level—bacterial and blue-green algal cells without the internal structures (nucleus, mitochondria, and others) that make sex and complex metabolism possible. For perhaps 3 billion years, the highest form of life was an algal mat—thin layers of prokaryotic algae that trap and bind sediment. Then, about 600 million years ago, virtually all the major designs of animal life appeared in the fossil record within a few million years. We do not know why the ''Cambrian explosion'' occurred when it did, but we have no reason to think that it had to happen then or had to happen at all.

Some scientists have argued that low oxygen levels had prevented a previous evolution of complex animal life. If this were true, the ratchet might still work. The stage remained set for 3 billion years. The screw had to turn in a certain way, but it needed oxygen and had to wait until prokaryotic photosynthesizers gradually supplied the precious gas that the earth's original atmosphere had lacked. Indeed, oxygen was probably rare or absent in the earth's original atmosphere, but it now appears that large amounts had been generated by photosynthesis more than a billion years before the Cambrian explosion.

Thus, we have no reason to regard the Cambrian explosion as more than a ''fortunate'' event that need not have occurred, either at all or in the way it did. It may have been a consequence of the evolution of the eukaryotic (nucleate) cell from a symbiotic association of prokaryotic organisms within a single membrane. It may have occurred because the eukaryotic cell could evolve efficient sexual reproduction, and sex distributes and rearranges the genetic variability that Darwinian processes require. But the crucial point is this: if the Cambrian explosion could have occurred any time during more than a billion years before the actual event—that is, for about twice the amount of time that life has spent evolving since then—a ratchet scarcely seems to be an appropriate metaphor for life's history.

If we must deal in metaphors, I prefer a very broad, low, and uniform slope. Water drops randomly at the top and usually dries before flowing anywhere. Occasionally, it works its way downslope and carves a valley to channel future flows. These myriad valleys could have arisen anywhere on the landscape. Their current positions are accidental. If we could repeat the experiment, we might obtain no valleys at all or a completely different system. Yet we now stand at the shoreline contemplating the fine spacing of valleys and their even contact with the sea. How easy it is to be misled and to assume that no other landscape could possibly have arisen.

I confess that the metaphor of the landscape contains one weak borrowing from its rival, the ratchet. The initial slope does impart a preferred direction to the water dropping on top—even though almost all drops dry before flowing and can flow, when they do, along millions of paths. Doesn't the initial slope imply weak predictability? Perhaps the realm of consciousness occupies such a long stretch of shoreline that some valley would have to reach it eventually.

But here we come upon another constraint, the one that prompted this column (although I have been, I confess, a long time in getting to it). Almost all drops dry. It took 3 billion years for any substantial valley to form on the earth's initial slope. It might have taken 6 billion or 12 or 20 for all we know. If the earth were eternal, we might speak of inevitability. But it is not.

Astrophysicist William A. Fowler argues that the sun will exhaust its central hydrogen fuel after 10 to 12 billion years of life. It will then explode and transform to a red giant so large that it will extend past the orbit of Jupiter, thus swallowing the earth. It is an arresting thought—the kind that makes you stop and contemplate or that sends shivers up and down your spine—to recognize that humans have appeared on earth at just about the halfway point of our planet's existence. If the metaphor of the landscape is valid, with all its randomness and unpredictability, then I think we must conclude that the earth need never have evolved its complex life.

It took 3 billion years to go beyond the algal mat. It might as well have taken five times as long, if only the earth had endured. In other words, if we could run the experiment again, the most spectacular event in the history of our solar system, the explosive exhaustion of its parent, might just as well have had an algal mat as its highest, mute witness.

Alfred Russel Wallace also contemplated the eventual destruction of life on earth (in his day, physicists argued that the sun would simply burn out and the earth freeze solid). And he could not accept it. He wrote of

> the crushing mental burthen imposed upon those who . . . are compelled to suppose that all the slow growths of our race struggling towards a higher life, all the agony of mârtyrs, all the groans of victims, all the evil and misery and undeserved suffering of the ages, all the struggles for freedom, all the efforts towards justice, all the aspirations for virtue, and the wellbeing of humanity, shall absolutely vanish.

Wallace eventually opted for a conventional Christian solution, the eternity of spiritual life: ''Beings . . . possessing latent faculties capable of such noble development, are surely destined for a higher and more permanent existence.''

I would venture a different argument. The average species of fossil invertebrate lives 5 to 10 million years, as documented in the fossil record. (The oldest may go back, although I doubt the story myself, more than 200 million years.) Vertebrate species tend to live for shorter times. If we are still here to witness the destruction of our planet some 5 billion years or more hence, then we will have achieved something so unprecedented in the history of life that we should be willing to sing our swan song with joy—*sic transit gloria mundi.* Of course, we might also fly off in those legions of space ships, only to be condensed a bit later into the next big bang. But then, I never have been a keen student of science fiction.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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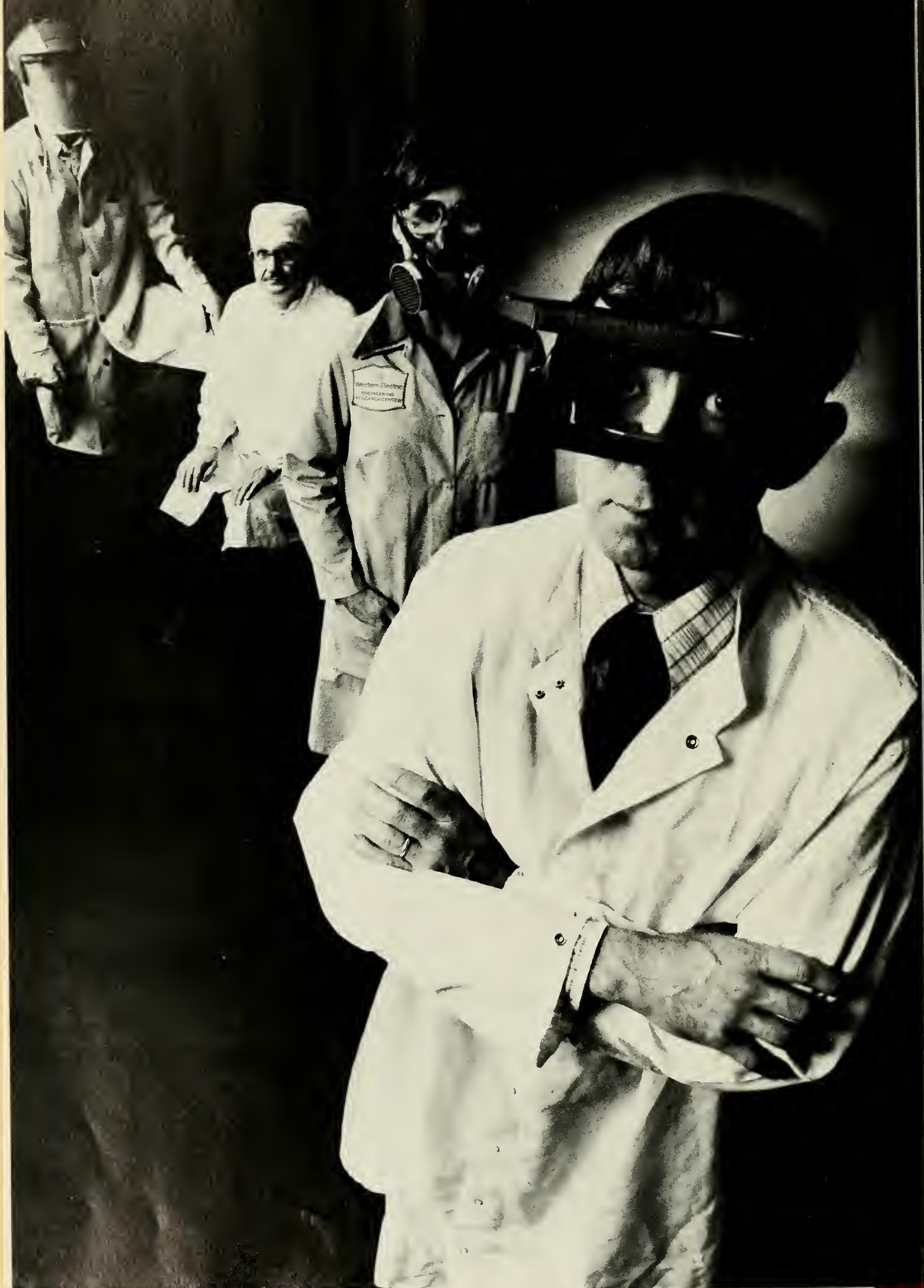
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# Hyenas of the Kalahari

*In the desert, sometimes it pays to be a lone scavenger and other times to feed communally. It all depends on the season*

The night air is filled with sharp, rasping cries and heavy breathing. Dry, brittle grass cracks beneath the stumbling feet of two brown hyenas. Face to face, they spar—now thrusting, now parrying—their long canines glistening white in the moonlight. Then from one comes a high-pitched sound, not unlike a human scream, as its neck is seized by its opponent's powerful, viselike jaws. Dust explodes from the ground as the hyena is shaken like a rag doll and blood spreads through its blond neck hairs. After several minutes, it breaks the adversary's grip and lopes away pursued by the victor. Soon, however, both hyenas return to the carcass they were fighting over and begin feeding side by side as though nothing had happened.

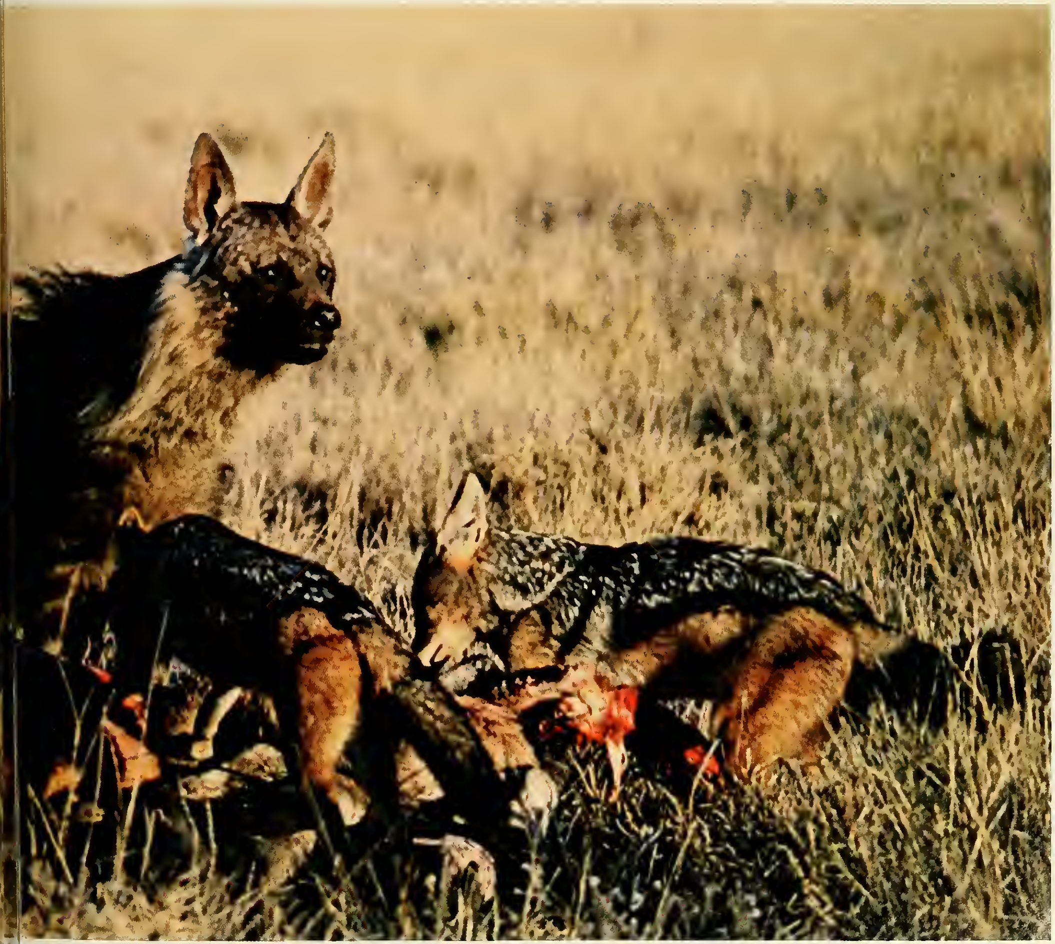
Brown hyenas have always been considered solitary animals, but the above scene involved one of many fascinating social interactions we have observed during a five-year study of these carnivores. Since they are shy and nocturnal, these animals are difficult to study in the wild and have been the object of many misconceptions. In the vast central Kalahari wilderness of

### by Delia Owens and Mark Owens

Botswana, however, we located a population that had probably never before encountered modern man and thus did not fear us.

Confined to the arid and semiarid regions of southern Africa, brown hyenas differ greatly in appearance and behavior from the better known spotted hyena. They have striped gray legs and a long blond mane over the neck, and their sloping back is covered with long dark hair. They stand about two feet at the shoulder and weigh about 110 pounds compared with the spotted hyena's 165 pounds. Of particular interest is the brown hyena's social system, which differs in many ways from that of its spotted cousin.

The brown hyena's social organization is molded by its feeding habits,



*Black-backed jackals swarm over a gemsbok carcass on which a lone brown hyena had been feeding. By disrupting feeding hyenas, the jackals compete effectively as scavengers.*

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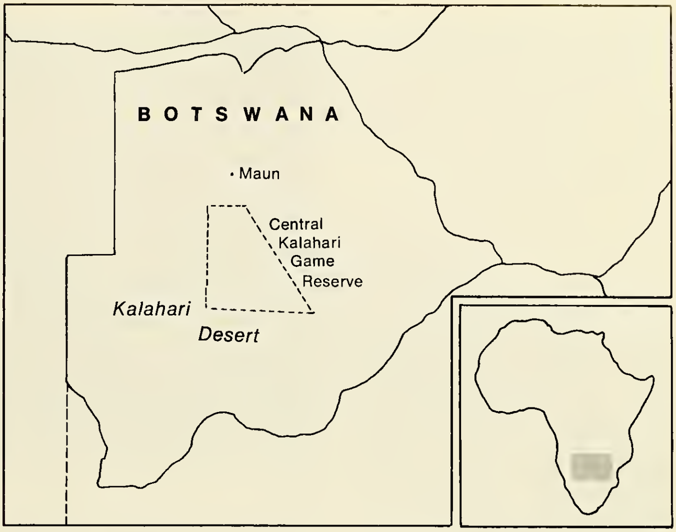
which are dictated by a harsh environment. The influence of niche exploitation on social organization has been demonstrated by Hans Kruuk in his research on other members of the family Hyaenidae. Kruuk has shown that spotted hyenas separate to scavenge or hunt small prey, but they also form highly coordinated groups to hunt larger prey such as wildebeest or zebra. For scattered individuals, each with its own goals, to be suddenly welded into a well-oiled, efficient hunting machine, much social integration must be accomplished in a very short time. Communication by means of complex visual, vocal, and olfactory signals sublimates individual interests and aggression and brings about the cooperation needed for success in the hunt. Thus, spotted hyenas possess a flexible social organization that reflects the size of prey to be hunted.

Another species, the striped hyena, feeds only on small food items—insects, rodents, fruits. Because they do not need any degree of social integration or tolerance to catch small prey, striped hyenas are solitary animals.

The effects of brown hyenas' feeding habits on their social organization can best be understood in terms of the often fickle central Kalahari environment. The seasonality of rainfall, for example, has a strong influence on what brown hyenas eat.

Our research is centered on Deception Valley in the huge Central Kalahari Game Reserve. Seven times larger than the Serengeti Plains, the approximately 33,000-square-mile reserve is one of the largest game protectorates in the world. Except for a few bands of roving Bushmen, we are the only inhabitants of this vast, untouched wilderness. The logistics of working in this remote area, where we even have to make our own maps, are formidable, but the rewards of conducting research in a pristine environment are compensation enough.

The central Kalahari is not a true desert, receiving sufficient moisture—up to twenty inches of rainfall between November and March—to support a cover of vegetation. The area has none of the naked, shifting sand dunes that typify some of the other great deserts of the world. But after the rains the area is dry for eight months or more, and periodic droughts lasting several years are not uncommon.



The topography is gently rolling, homogenous thornveld, transected by three major fossil river systems, the Passarge, Deception, and Okwa valleys. In more pluvial times these ancient river systems carried water to the Makarikari, a huge inland lake to the northeast. Today, these rivers never flow and the valley slopes are stratified with highly diverse habitat types essential to a wide variety of desert species.

The meandering channels of the ancient rivers have become narrow, open savannas where herds of springbok, gemsbok, hartebeest, and a few wildebeest graze on the short, nutritious grasses during the rains. The dune slopes bordering the riverbed are bush savanna, covered with taller grasses and scrub *Acacia*, which sustain such species as eland, steinbok, and duiker. The dune tops sport an open to fairly dense woodland of *Acacia, Terminalia*, and *Combretum* trees, which are browsed by greater kudu and giraffe.

The central Kalahari is also rich in small animals, such as porcupines, springhares, mice, reptiles, and insects, which are seasonally important prey species for all the major predators, including brown hyenas.

Following the influx of prey species to the fossil river valleys at the onset of the rains, lions, cheetahs, leopards, and wild dogs join the resident brown hyenas and black-backed jackals, and the predation frequency increases immensely. With the kills, abundant carrion becomes available to brown hyenas and jackals.

Almost with the last roll of thunder in late March or early April, the sun takes on a baleful look as though determined to burn away every drop of moisture brought by the rains. The long dry season has begun. As the water holes and grasses lose moisture, the springbok, gemsbok, and other plains grazers assume a different life style; they begin including more browse in their diets, leaving the riverbeds for the bushy vegetation found on the dune slopes. The dune soils' deep, porous sand acts as a sponge, soaking up and retaining moisture from the rains. Thus the shrub and herbaceous species growing there remain succulent for long periods, and the browse from these plants sustains the herbivores during the long dry months. By mid-July, the only sign of the past presence of ungulates on the ancient riverbeds are tracks in the crusted mud of dry water holes and dusty game trails that wind along the valley.

Brown hyenas are highly adapted for the role of predator-scavenger in the Kalahari where they must make use of a wide variety of food sources. Their adaptable nature is especially put to the test by the rigors of the long dry season. To avoid the heat, browns are pri-

*Using its rear teeth, a brown hyena gnaws on the rounded stumps of a giraffe's upper leg bones. The huge animal had been killed by lions two nights earlier in the Passarge region of the Kalahari.*

Pe Johnson

*A favored trick of jackals is to sneak up behind a feeding hyena and nip the larger scavenger on its rear. While the hyena whirls around, the swift jackal dashes in to grab a bite out of the carcass. Hyenas will often attempt to chase the jackals, but in hundreds of observed chases, only one jackal was bitten.*

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marily nocturnal, lying up in holes or under thick bush during the day. After rising in the early evening, a hyena begins a long trek in search of food. Often covering distances of eighteen miles or more in a night, the hyena frequents those habitats most utilized by ungulates and small prey. In this season few items are too old or insipid to serve as food. Months-old bones, horns, and hoofs—the remains of kills made by other predators during the rains—are scavenged and assimilated by the hyena's remarkable digestive system. These remains are present in 33 percent of fecal samples collected at this time of year. Browns also scavenge the dung of large predators and ungulates. A favorite food is ostrich eggs, which are eaten at the nest or cached for a later meal.

Brown hyenas are also predators, and the small prey taken can be an important dietary supplement in the dry season when the carrion resource is much diminished. At this time of year, the hyenas hunt more frequently, spending much less time on the now barren riverbed and more time in the thick bush of the sandveld. The most common prey taken are rodents and birds. Browns also hunt hares, bat-eared foxes, and other small mammals. While insects do not represent a large proportion of the food intake in terms of volume, in the dry months they are found in 16 percent of the feces. Hyenas take an occasional lizard or snake, but reptiles are not important dietary components in the central Kalahari.

Brown hyenas use a simple hunting technique. While they may achieve speeds in excess of forty miles per hour, they are not dexterous in turns. When in pursuit of a rat, the hyena makes a short, lumbering dash; when hunting a springhare, a long zigzag chase. Chases may cover more than a half mile, after which, if successful, the hyena grabs the prey and gives it a quick shake. Browns occasionally stalk birds, lowering their body felid style and taking halting, abbreviated steps before lunging as the prey takes flight. Of all hunting attempts, excluding insects, fewer than 10 percent are successful.

During the dry season, lion prides double the size of their home ranges and are widely scattered. While lion kills are the most important source of carrion, the browns also often appropriate meals from the smaller black-backed jackals. Mammal, bird, and snake kills are stolen from jackals, whose diet consists mostly of small prey they kill themselves. One night as we were following a female brown hyena, she suddenly changed course and ran 450 yards through thick bush to where two jackals had killed a kori bustard. As she dashed in and grabbed the bird, the jackals scattered. Within fifteen minutes, two other browns were attracted to the scene, perhaps demonstrating how important such food items are in the dry season.

Among the most essential elements of the hyena's dry season diet are the fruits of wild melons. Seeds and rinds of the tsama, gemsbok, and hookeri melons make up as much as 50 percent by volume of the animal's dry season feces. There is no standing water anywhere in the central Kalahari for up to eight months, so brown hyenas must extract their moisture requirements from the fluids of prey or from fruits.

Smell is the major sense used in locating food. In many places the hyena cannot see more than a few feet ahead as it walks along in the tall grass and thick bush. Foraging hyenas often turn abruptly into the wind and hold their muzzle high to locate a scent. One adult female we were following turned 120 degrees upwind, raising her muzzle. She then ran a third of mile through thick bush to where a gemsbok was giving birth and attempted to approach it, but moved off after being charged three times.

Of the food items available in the dry season, few are sufficiently large to meet a brown hyena's minimum daily requirement. The hyenas could not profitably forage in groups and must therefore spend much of the dry season traveling alone over large areas.

How does the brown hyena exploit such extremely varied resources as the sparsely distributed food items of the dry season and periodic droughts and the concentrated carrion supplies of the rains? While the brown hyena is an opportunist par excellence, efficient occupancy of the scavenger's niche in such a changeable environment as the Kalahari requires more than simple opportunism. With food supplies ebbing and flowing throughout the ecosystem according to fickle rainfall patterns, how are resources apportioned among individuals during the good and bad times? How does a female find enough to feed herself and her young during the long dry months? Who tends the young while she is foraging, sometimes for days? The answers to these questions lie in the brown hyena's social system.

Like spotted hyenas, browns live in clans. A brown hyena clan consists of three to four adult females, their young of varying ages, a number of suba-

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dults, one dominant male, and usually no more than two or three subordinate males. The typical clan numbers ten to thirteen animals. Adult clan members maintain a social hierarchy through ritualized fighting that includes neck biting, muzzle wrestling, chasing, and other social displays.

The clan defends a territory of about 100 square miles against neighboring clans. Defense of territory is usually limited to scent marking the boundary; foreign hyenas that trespass are chased and severely bitten on the neck by clan members.

Like many social animals, brown hyenas have a highly developed communication system. Although they do not "laugh" as do spotted hyenas, they possess a repertoire of vocalizations. These are important only for close-range communication, however, and cannot be heard at a distance greater than several hundred yards. The most important means of communication is olfactory investigation of individuals and scent marking. As hyenas traverse their territory, they scent mark, or "paste" anal gland secretions to grass stalks, as often as once every two or three minutes. The paste apparently contains spatial-temporal impressions and information on individual identity and social status, which permit the animals to avoid or locate each other.

One night, for example, Star, a female we have known for five years, pasted a grass stalk at a water hole, then moved south. Twenty minutes later, Patches, a dominant female, approached the pasted stalk, smelled it, and with hackles bristling, altered her course and began walking quickly in the direction Star had taken. She overtook Star about a mile south of the water hole, and chased and neck-bit her for twenty minutes. On another occasion, a hyena threatened another hyena's paste that had become attached to our truck bumper as we drove through the grass. Brown hyenas also paste near such items of interest as carcass sites, water holes, and points where they have cached food.

In their travels, clan members utilize, and maintain through pasting, an extensive network of common pathways, frequently meeting, greeting, and then moving on together or separating to forage alone. When brown hyenas meet, they may simply greet by raising their tails while engaging in mutual anus sniffing, but this greeting often develops into a bizarre ritual we call the "carpal crawl." Lowering itself to its knees with tail raised and lips drawn up in a "grin of appeasement," the subordinate individual crawls around the other. The dominant smells under the tail of the subordinate as both pirouette in a small circle. The dominant breaks contact by simply walking away, only to have the subordinate get up, follow it, and initiate the interaction again by lying down in front of the dominant. We have seen this ritual occur in this leapfrog fashion as many as five times. The entire affair is accompanied by a squeak, sounding somewhat like a rusty gate hinge, emitted by the subordinate hyena.

During the rains, greater amounts of carrion are left on and near the fossil riverbed by the lions, leopards, and cheetahs that focus their hunting efforts on the large ungulates concentrated in the relatively confined area of the range. Carcasses abandoned by lions, or those appropriated by chasing leopards, cheetahs, jackals, and servals from their kills, constitute the most important food resource for brown hyenas at this time of year.

Since brown hyenas depend so heavily on carrion, they have developed distinct relationships with other carni-

vores. They never feed with lions but periodically visit the general area where the big cats are feeding on a kill, taking great care not to venture closer than about 225 yards. The reason for this became obvious to us one night while two large male lions slept within seven feet of the rear of our Land Rover. After some time a brown hyena appeared, moving silently toward us over the bright, moonlit riverbed. The hyena knew us well and approached from the front; the vehicle obscured its view of the sleeping lions. As the hyena passed the rear of the truck, the lions sprang up and began batting the screaming hyena back and forth between them as though playing tennis. Afraid to expose its rear, the hyena kept howling and backpedaling until it finally found an avenue of escape into thick bush at the edge of the riverbed. It was apparently not seriously injured, as we saw it again soon after the incident. Nevertheless, lions do kill browns, and even after a pride has left a carcass for a considerable time, hyenas approach with great caution.

Hyenas frequently chase cheetahs and leopards from their kills. One night a male leopard killed an adult springbok just outside our camp. One of our ear-tagged female hyenas chased the leopard off before it started feeding. Later, the leopard returned to the kill while the hyena was feeding. Raising its tail over its back, the leopard charged the hyena. She countered by raising her tail and mane, then charged straight at the leopard and chased it 500 feet into our camp and up a tree before returning to the carcass. We have also seen hyenas chase leopards into trees on several occasions when there was no kill in contention.

Although spotted hyenas and wild dogs dominate brown hyenas, there are so few of them in the central Kalahari that they cannot be considered serious competitors.

Brown hyenas interact most frequently with black-backed jackals since these little predators are numerous and their diet greatly overlaps that of the hyena. Up to fifteen jackals will compete with a hyena on a carcass, often pulling at one end while the hyena feeds at the other. The hyena frequently interrupts its feeding to chase them off, but the jackals are too quick for the hyenas, and in hundreds of these chases that we observed, only one jackal was bitten across the back

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*During the rainy season, large herds of springbok, above, and other ungulates provide ample prey for large carnivores. The leftover carcasses are a major food source for hyenas in the Kalahari.*

when it was caught unaware by the hyena. A jackal may at times creep in to nip a hyena on the rear, and as the hyena turns, the crafty little scavenger darts around the opposite side, snatching a piece of the carcass. Jackals are highly effective competitors not only because of the amount they can consume but also because they persistently disturb the feeding hyena.

When a large carcass such as a gemsbok is left by lions, enough meat, skin, and bones remain to attract hyenas for several nights. The hyenas must be able to dissolve individual differences and achieve a state of social tolerance at a carcass so that they can feed together. Behavioral mechanisms such as visual signals, vocalizations, and ritualized contests provide the communication necessary for brown hyenas to associate. Meetings at a carcass constitute a social affair where behaviors such as neck biting, muzzle wrestling, chasing, and the carpal crawl are prevalent.

Neck biting, the ritualized form of combat in brown hyenas, often begins with muzzle wrestling. The hyenas stand face to face, turning their heads this way and that, throwing their muzzles up high and hard against each other. Their mouths are wide open and teeth exposed. Once one of the animals has the other by the neck, the outcome of the contest has been decided. The victor then often shakes the loser so vigorously that the latter's feet are lifted off the ground. The sound of teeth cutting skin can be heard. Finally, the loser is thrown to the ground; the winner stands over it, shaking and biting for up to eighteen minutes. The rattling cry of the now subordinate hyena can be heard for several hundred yards. After disputes of dominance in the social hierarchy are settled by these contests, the hyenas feed together with seldom a sign of aggression.

When the concentrated food resources of the rainy season are gone, the clan's home-range size doubles. Even though they are widely dispersed, clan members maintain contact through the system of olfactory pathways.

The way in which brown hyena females raise their young is ultimately a reflection of their feeding habits. Brown hyena females give birth to one to four cubs in a small maternity den located within the clan's territory. The female attends her cubs once or twice nightly and may move them to three or four new locations. When they are two and a half months old, cubs are installed in a final maternity den near the clan's large communal den. In this location, cubs are gradually introduced to adults and subadults. After a few days in this den, the cubs are carried by their mother to the communal den where they are installed with other young of varying ages. The estrus of adult females appears to be staggered so that only one litter of very young cubs resides in the communal den at any time. The communal den is the answer to the problem of "what to do with the cubs when you have to work all night." It is a type of hyena crèche or kindergarten. Once the cubs are in the communal den, all lactating females indiscriminately suckle cubs until they are approximately fourteen months old. Females, with and without cubs, and young male relatives of the cubs participate in raising the young by bringing food items to the den.

Several advantages accrue to the hyena population from communal denning. After infant cubs are brought to the den, the mother begins spending less time visiting them and is often away for two or three nights. In her absence, the den is the cub's only defense against predators. At the first sound of any animal approaching, small cubs dive through one of the den openings and take refuge in cavities they have previously dug in the walls. Larger cubs "stand tall" at the den entrance. With hackles raised, tails curled over their backs, and heads held high, they present a formidable appearance that often discourages some predators, such as wild dogs, from approaching. If a lion is seen, however, all cubs take instant refuge within the den and stay there until the danger has passed.

Released from the responsibilities of close attendance on cubs, clan females can spend more time foraging. This enhances their chances of locating a carrion surplus, such as a giraffe or gemsbok carcass, portions of which can be transported to the cubs at the den. The advantages of collective food provision by females and the security provided by the den facilitate the survival of all the cubs.

Another benefit of communal denning is that it provides much opportunity for play and social development. Each evening, just after sunset, cubs engage in a riotous "happy hour" of play. Chasing, muzzle wrestling, and neck biting with shaking are all on display as cubs perfect those ritual behavioral mechanisms that will secure them a place in the social hierarchy as adults.

As the cubs reach adolescence, they leave the den for short periods to forage on their own, returning to sleep nearby during the day. At sunset adolescents go to the den to play or rest with smaller cubs until an adult female arrives. After having attended to the cubs, the female leaves to forage, and the adolescent cubs tag along begging food. They also begin learning the network of paths and, in general, the lessons of the scavenging way of life. As adolescents reach subadulthood, however, adults begin rebuffing them with severe neck biting. By about thirty months of age, the young hyenas must forage solitarily, and some males are excluded from the clan.

Soon they will be full adults, with a binary social mode—at times solitary, often social. They will be behaviorally equipped to utilize the seasonal variety of food resources in the central Kalahari ecosystem. During dry times, they will hunt or forage as individuals, and during wet times of plenty, they will come together as social scavengers. Both roles enable them to survive in a harsh land. ☐

Delia and Mark Owens

*Ritualized combat, such as this neck biting at the carcass of a gemsbok, serves to establish relative status within a clan. The biting may be so vigorous that one hyena will be thrown off its feet and its mane colored with blood from open wounds.*

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**NORTH CAROLINA**

# Daddy Water Bugs

*The eggs of many species of giant water bugs are carried and cared for by the males*

**Text and photographs by Robert L. Smith**

Giant water bugs of the family Belostomatidae lurk in the shallows of ponds and streams throughout the temperate and tropical regions of the world. These drab brown, flattish insects resemble dead leaves, but their innocuous appearance is deceptive, for all species, from the smallest (two-fifths inch) to the largest (about five inches), are voracious predators. The water bug employs an ambush strategy, waiting motionless for unsuspecting prey to seek sanctuary under its leaflike form. The victim is seized with strong, raptorial front legs and stabbed with a stout, hollow beak. An anesthetic fraction in the water bug's saliva chemically lulls the prey into a terminal sleep. Other constituents of the saliva are proteolytic and immediately begin to liquefy prey tissues. The resultant rich soup is imbibed by the bug through its strawlike mouth.

With few exceptions, giant water bugs are opportunistic, indiscriminate predators. Their rapaciousness is legendary. Although they usually feed on aquatic animals smaller than themselves, they have been reported to attack and successfully subdue prey many times their own size and weight. Several of the larger species regularly capture frogs, water snakes, and fish up to a foot long. There are two independent accounts of large belostomatids having taken plovers. The birds apparently were attacked while wading and managed to struggle ashore with their molesters hanging on tenaciously. A postmortem on one of the plovers found in a moribund condition disclosed that the bug had been feeding on the bird's liver. Their grandest prey is revealed by the common name applied to species that inhabit streams in Mexico and the southwestern United States, "toe biters."

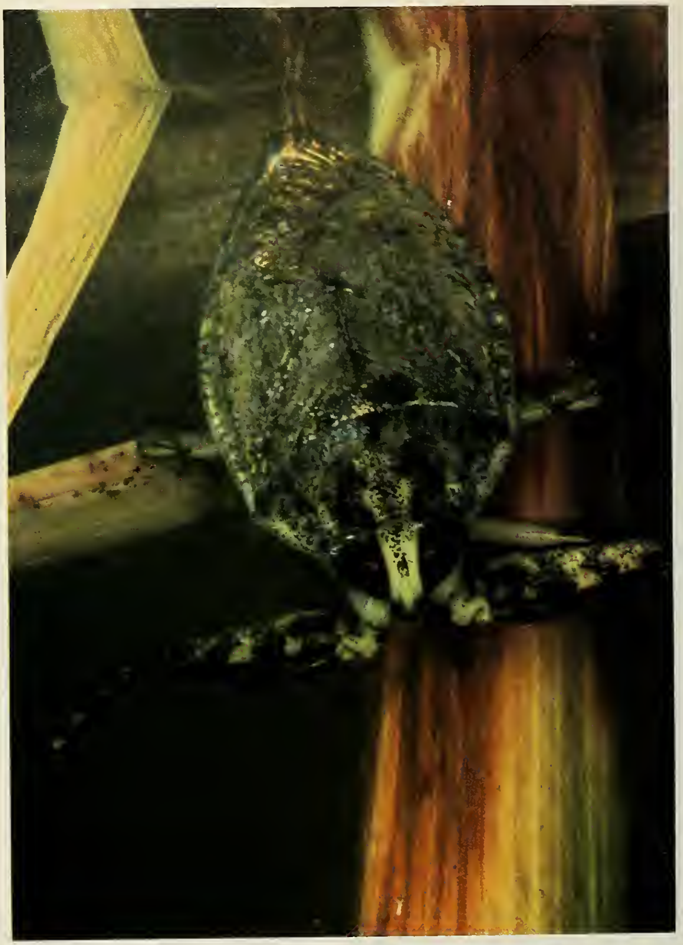
In a vindictive turn of the table, the people of Southeast Asia collect large numbers of giant water bugs, boil them in brine, dry them, and market them as a sort of entomological potato chip. Some cultures in that part of the world value the aromatic thoracic exudate of certain species as a food seasoning.

I was attracted to the giant water bugs, not by their predatory prowess or their ethnoculinary importance, but rather by the unusual reproductive behavior of species belonging to the largest subfamily, the Belostomatinae. Males and females in this subfamily do not follow what we might consider the customary parental roles. Female bugs glue their eggs to the backs of their mates and, having done so, leave the encumbered males to care for and brood the eggs until the young nymphs are hatched, fifteen to thirty days later.

Before the turn of the century, scientists believed that the brooders were females carrying their own eggs. Some (male) authors, apparently influenced by their chauvinistic preconceptions, went to the extent of inventing theories of the oviposition process, which they attributed to a long protrusile ovipositor the female bug was said to extend over her back. It took a woman scientist, Florence W. Slater, to set the record straight, although the charming 1899 report of her discovery reveals something less than complete eman-

*Giant water bugs are voracious predators, often attacking prey many times their own size. Left, a water bug nymph consumes the liquefied tissues of a dragonfly naiad through its strawlike mouth.*

*A water bug (*Lethocerus medius*) waits motionless on a cattail stalk, ready to ambush an unsuspecting victim. "Air straps" projecting from the rear of the bug provide access to atmospheric air.*



*A brooding male (*Abedus herberti*) acquires a store of air at the water's surface. If confined in a tank without foliage for support, such a male will drown unless he is able to kick off his load of eggs.*

cipation. "That the male chafes under the burden is unmistakable," she wrote. "In fact, my suspicions as to the sex of the egg-carrier were first aroused by watching one in an aquarium, which was trying to free itself from its load of eggs, an exhibition of a lack of maternal interest not expected in a female carrying her own eggs." Slater went on to say that when the male was attacked (by an unidentified agent), "he meekly received the blows, seemingly preferring death to the indignity of carrying and caring for the eggs." Not long after, the famous entomologist J.R. de la Torre Bueno, in apparent accord with Slater's humiliated male hypothesis, wrote:

> The egg-bearing male . . . dislikes exceedingly this forced servitude, and does all he can to rid himself of his burden. From time to time he passes his third pair of legs over the eggs, apparently in an endeavor to accomplish his purpose. If he is not able to get rid of it, as sometimes happens, he carries his burden till in due time all the little ones are emerged, when he at last frees himself from it.

These interpretations appear quaint in the light of modern evolutionary theory. Natural selection could not have favored females programmed to dispose of their eggs on the backs of males if these eggs were then to be discarded in places or conditions unfavorable to their development. On the contrary, it is important for oviparous females of all species to deposit their eggs in places that will tend to maximize egg success and give the young the best possible start in life. Following this reasoning, I set out to confirm that the back of a male water bug is the optimal substrate for water bug eggs.

*Belostoma flumineum*, the bug whose behavior previous workers had observed, is one of the most common United States species, occurring in the shore areas of ponds from coast to coast. I quickly located some in a pond at Papago Park in Phoenix. While collecting bugs to establish a laboratory population, I observed egg-covered males perform the remarkable behavior pattern mentioned by de la Torre Bueno: they vigorously stroked the eggs on their backs with their hind legs, which are lined with long swimming hairs. Most applied a series of several strokes with one leg, rested, then stroked repeatedly with the other.

This stroking behavior seemed more nurturant than malevolent. I wondered if the male bugs were performing an essential task, stroking to insure eggs a constant supply of freshly oxygenated water while at the same time removing toxic embryonic metabolites. If so, eggs removed from a male's back and submerged in standing water might fail to develop. In the laboratory, I removed the gelatinous egg pads from the backs of males and placed them in deep dishes. I covered half of these eggs with several centimeters of water; the other dishes were left dry. As a control for this simple experiment, I placed several encumbered males in identical containers filled with water. The next day, I was discomfited to find that a few of the control males had died, and that the rest had somehow removed their egg pads. Slater's and de la Torre Bueno's words flashed through my mind: "dislikes exceed-

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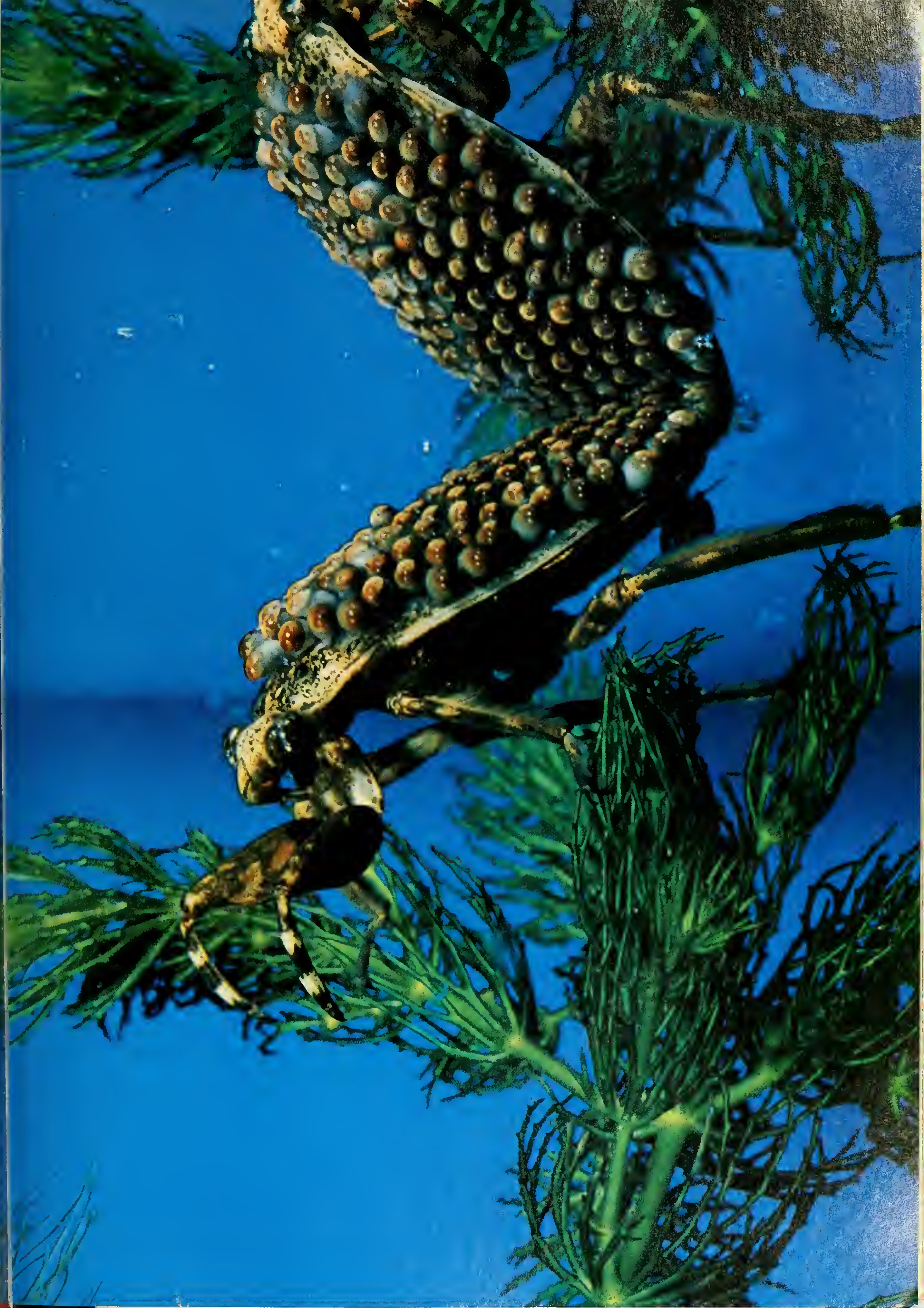
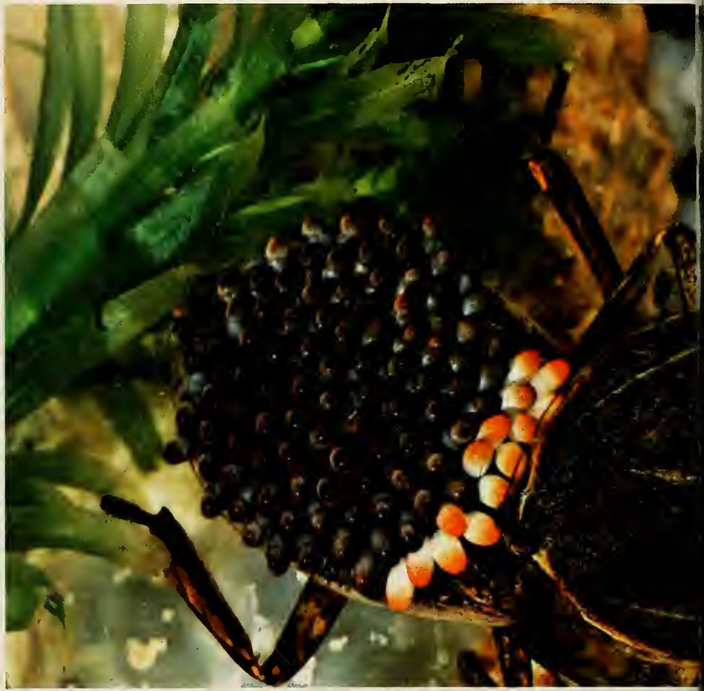


*Between bouts of mating, a female* Abedus herberti *deposits the fertilized eggs on the male's back, where they soon darken. Females will reject a male if he has no brooding space to offer.*



ingly," "to rid himself of the burden," "seemingly preferring death."

Turning to the holding tank that contained the rest of the bugs in a tangle of filamentous algae and other aquatic plants, I fully expected males either to have died or to have shed their egg pads, but found most of them resting happily on the aquatic plants with their eggs exposed above the water's surface. Others were below the surface stroking their eggs as I had observed in the field. A small mystery had been solved. Apparently, previous observers had placed egg-laden bugs in aquariums lacking vegetation that would permit passive resting at the surface.

The giant water bug lacks gills. It obtains a store of air at the surface by extending out of the water a pair of special posterior respiratory organs called air straps. The air straps, densely covered with water-shedding hairs, provide a pathway for atmospheric air, which is drawn into a reservoir under the wings, where it is available to the bug through abdominal and thoracic spiracles, or breathing holes. This permits the water bug to be active underwater, much as an aqualung allows a skin diver to explore the depths. But the water bug, like the aquanaut, must surface periodically to renew its supply of oxygen. Female and unencumbered male bugs float effortlessly for prolonged periods with their air straps extended out of the water. An egg-laden male cannot. The mass of the eggs (up to two times the male's eggless weight) weighs him down, altering his center of gravity so that he floats horizontally, with the air straps below the water's surface. An encumbered male must kick his hind legs repeatedly in order to pop his posterior through the surface film and obtain a quick "breath" of air. Apparently a bug cannot long sustain this procedure without exhausting himself and drowning. Little wonder that a male confined to open water should opt to relieve himself of his burden by kicking at the egg pad until it falls off.

As I had anticipated, the unattended eggs failed to hatch. All eggs in static water developed a fungus, and those left in open air desiccated. In contrast, of those left on the backs of males in water containing aquatic plants, 95 to 100 percent hatched. Males had indeed been brooding their eggs by exposing them to atmospheric air and circulating water over them while underwater.

*Abedus herberti*, another species of belostomatid, has evolved a different brooding pattern. It inhabits slow-flowing streams rather than ponds, and apparently sometimes needs all six legs to hold its position against the force of a changing current. Like *B. flumineum*, it frequently rests in emergent vegetation with its eggs exposed to the atmosphere; but when below the surface, rather than stroking, males do "push-ups" (rock back and forth longitudinally) to circulate water over their eggs. Only occasionally do they pat the eggs with a hind leg to confirm their presence. If the egg pad is removed, the male stops brooding.

In observing *A. herberti*, I also found that the brooding male declines to feed on young nymphs, even if very hungry. This inhibition may protect the male's investment if most of the young nymphs he is likely to encounter have recently hatched from his back and hence contain his genes. Significantly, females and unencumbered males are in no way restrained from cannibalizing nymphs. In the contentious ecological economy of these creatures, an unrelated conspecific nymph is a competitor with no value as a mate; its only utility to an adult resides in the calories it contains. Another seemingly peculiar but adaptive form of cannibalistic behavior is the male's habit of "sucking" eggs that fall or are kicked from his back. While these eggs almost certainly contain the brooder's genes, they have little or no chance of developing after being detached from the male. So, the cannibalistic male is simply recovering a portion of his lost investment in the form of nutrient.

Brooding is not without cost to male water bugs. The added weight and irregular wetted surface of the eggs slow a swimming bug considerably, and the dynamics of brooding (push-ups or egg stroking) undermine his cryptic strategy. These factors almost certainly reduce the brooder's predatory efficiency and may subject him to greater risks of predation. Also, a bug cannot spread his wings and fly when they are covered with eggs, so he forfeits dis-

persal options. But by far the most significant sacrifice is the loss of opportunity for polygynous mating: females reject the encumbered male because he has no brooding services to offer.

Females of almost all species have been selected to invest more heavily than males in the production of young. This differential investment begins with the female's production of relatively enormous gametes. Eggs that contain genetic instructions and nutrients are thousands of times larger than sperm, which contain genes and very little else. And where parenting occurs, it is usually the female that is obliged to nurture the embryos and young for a protracted period. Males typically maximize their contribution to the future gene pool by mating with as many females as possible. When a male participates in the rearing of young, he pays a price in time and reduced opportunities for mating. As previously mentioned, nurturant male water bugs forfeit the opportunity to mate for the duration of brooding.

Although exclusive male brooding is exceedingly rare among insects (and other animals as well), reproductive economics have occasionally favored its development. When it does occur, males should be very selfish about whose eggs they brood. A male that contributes to the care of progeny other than his own (or those closely related to him) is said to be cuckolded, and natural selection is extremely intolerant of cuckolds. The genes for such unselfishness would be poorly represented in subsequent generations. A selfish male that broods only eggs or young containing his selfish genes assures their propagation.

Usually, male insects contribute nothing to reproduction beyond sperm and therefore are not threatened by cuckoldry. Paternal brooding giant water bugs are exceptions—they invest heavily and risk being cuckolded!

Female insects have sperm storage organs (spermathecae) that allow them to mate once and lay eggs over an extended period without the need to remate. Stored sperm is a serious threat to male water bugs that receive eggs from nonvirgin females. Males are incapable of determining if a female has previously mated, and because bugs do not pair bond, males do not have the opportunity to jealously guard their mates against alien insemination, as do other animals, including human males. Male water bugs have evolved a different paternity assurance mechanism. They insist on copulating several times with a female before receiving any of her eggs. After the initial round of coupling, a male allows the female only enough time to deposit two or three eggs on his back before he demands to copulate again. In order for a female to deposit all of her eggs on a male's back, she may be required to copulate more than one hundred times, and the alternating bouts of copulation and oviposition may consume up to two days. This is something of a zoological record, but the process serves male interests very well. By observing competitive matings involving a female and two males, one marked by a dorsal stripe (a genetically dominant trait), I have found that brooders are able to assure paternity of virtually all of the eggs they receive from previously mated females. This system protects males against cuckoldry even under fiercely competitive conditions where a single female is repeatedly mated to a series of different males.

A dramatic proof of the importance of this paternity assurance mechanism was provided by another experiment. I surgically removed part of a male water bug's ejaculatory duct, then paired him with a female previously mated to a genetically marked male. Although the surgically altered male coupled with the female, he could not ejaculate into and flush alien stored sperm from her reproductive tract. Consequently, the eggs he received for brooding were fertilized by the marked male. The vasectomized male had been cuckolded.

That males court females is generally true for the animal kingdom. Because of their usually greater contribution to reproduction, the female is selected to be cautious and choosy in courtship. She is careful to mate the best male from among many suitors, assuring that her offspring will have benefit of the best available male genes. Males are generally not so choosy; they tend to be promiscuous because they have little to lose and potentially much to gain from each successful mating. The male demand for willing females almost always exceeds supply, hence females are a "limited resource" for which males must compete vigorously. Competition among males may involve aggression or, more often, elaborate displays. Biologists conclude that females must prefer aggressive, showy mates, because the genes for these male characteristics are so common in animal populations.

What would happen if the male's reproductive investment were larger than that of the female? The water bugs may serve as a model. Although we have no precise measure of how many calories males and females actually invest in reproduction, it is clear that male water bugs make a substantially larger contribution than traditionally expected of their gender. My field studies of *A. herberti* indicate that for at least part of the year (the highly productive summer months) male back space may be limited. Do the females compete for and court their mates?

To some extent, this expectation is fulfilled: it is the female water bug that first and repeatedly approaches an initially passive male, who may reject these amorous advances. But most males answer with display; it is the nature of their display behavior that is unusual.

I was excited to discover that the male courtship display was a modified version of male brooding behavior—push-ups, executed at about ten times the brooding rate. A male's display demonstrates his ability to brood efficiently. Indeed, he shows himself to be so energetic that he can afford to display at a rate several times faster than necessary to assure development of eggs, and the female is duly impressed. It is not that female water bugs understand the relationship between good display and diligent brooding; it is simply that in the long run more eggs from females with a preference for display have hatched. This differential reproductive success has resulted in female populations composed almost entirely of those with the preference.

Although *A. herberti* females prefer mates that display, a heavily gravid female may lay her eggs on the back of a nondisplaying male if he is the only one available. This suggests that even in insects, well known for their fixed patterns of behavior, sexual roles in courtship may depend on conditions of the moment as well as on sex-linked genetic programs. When eligible males are limited, females may take what they can get; when males are abundant, females require a demonstration of their quality.

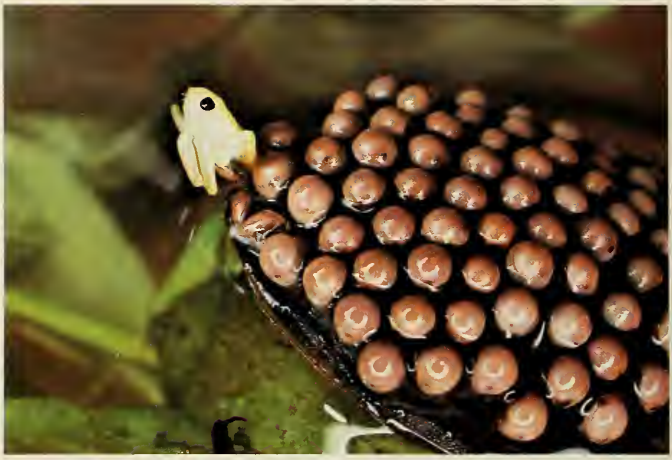
Female water bugs pay a price in time and added risks for male brooding. They could be feeding and making more eggs during the time expended complying with male demands for multiple copulations. Also, females occasionally drop eggs when interrupted by their mates to copulate. Both sexes are almost certainly more vulnerable to predation while mating because of their conspicuousness and preoccupation. But the nurturant father must have his way. He must assure paternity of the eggs he broods or the genes for paternal care will quickly disappear from the population.

Not all male giant water bugs are compelled to brood eggs. Females in what is believed to be the ancestral subfamily, the Lethocerinae, mate and then deposit their eggs on stout emergent vegetation (such as cattails) above the surface of the water. The eggs are left unattended until they hatch, and the young nymphs fall to the water. Male lethocerines are, therefore, at liberty to seduce as many females as possible.

This raises the most intriguing question about water bug biology. How were male Belostomatinae selected to sacrifice unrestrained polygyny for paternal care and serial monogamy? Simply stated: Why did males give up their promiscuous roving ways to become devoted fathers? I think the females had something to do with this.

Primitively, only nonbrooding water bugs must have existed. These species were almost certainly tied to aquatic habitats containing emergent vegetation for oviposition, as are the modern representatives of the group, which are found today the world over. The change in brooding habits must have taken place when, after mating, a "kinky" female, rather than laying her eggs on emergent vegetation, deposited some on a male's back. Actually this event may have occurred repeatedly over a relatively long span of time. Assuming that all brooders evolved from one parent stock, however, their development must have occurred some time before the supercontinent of Pangaea broke up and the continents began drifting apart, for today we find three genera of brooders in the Old World and two in the New World.

Males should have had no particular objection to the aberrant practice so long as they were free to pursue and mate with other females. Presumably, males decorated with a few eggs were no less attractive to conventional females who mated with them and went on attaching their eggs to emergent vegetation. Next we must assume that some eggs hatched from a male's back. When this happened, natural selection had something on which to operate. If the survival of male-borne eggs was greater on average than that of those laid on emergent vegetation, selection would have favored females with a penchant for laying eggs on males' backs. The difference in egg success may have resulted from differential parasitism, predation, and cannibalism of eggs on emergent vegetation over those carried by males. By comparing egg survival in modern brooders and nonbrooders sharing the same habitats, I hope to discover what was advantageous about the new strategy.



*An* Abedus herberti *nymph hatches, above and right. The male promotes the development of his brood by exposing the eggs to atmospheric air, and when underwater, by circulating fresh water over them.*

Whatever the explanation proves to be, male opportunities for polygyny diminished as more females demanded brooding services for their eggs. I suspect that this trend progressed very rapidly to fixation, or genetic universality in the population, such that encumbered males were rejected by all of the females they subsequently encountered. Clearly, males had little choice in the evolution of this new system; they could only attempt to compensate for their diminished opportunities for mating by honing their paternity assurance adaptations and increasing the survival of the eggs they received. Hence the evolution of repeated copulation and the elaboration of male brooding patterns.

Once male brooding had evolved, giant water bugs were no longer tied to habitats containing emergent vegetation. Consequently, the subfamily Belostomatinae rapidly proliferated and its new species invaded almost every possible aquatic habitat, from temporary ponds to the Sonoran Desert streams, where some devoted fathers and liberated mothers first caught my eye and captured my imagination. ☐

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# Snakes Shedding Skin

*How limbless ecdysiasts take it all off*

**by Leonard G. Appleby**

Ecdysis, or shedding of the outer epidermis, is one of a snake's most remarkable habits. It so impressed the ancients that they believed the snake to be immortal, being reborn each time it casts its skin. This is understandable to anyone who has seen a snake just after it has sloughed. Its colors then have the appearance of fresh paint and the snake itself is active and alert in striking contrast to its drab appearance and lethargic behavior just prior to skin shedding.

Why does a snake shed its skin? For much the same reason we do (although in scarcely noticeable fashion): to renew the outer epidermis as it becomes worn. Once it has formed, a snake's outer epidermis, or stratum corneum, keratinizes, a process that makes it tougher and more resistant to wear; this is important in view of a snake's close contact with the ground and the considerable friction that results. Keratinization not only makes a snake's integument resistant to abrasion but also prevents excessive loss of moisture from the body. In addition, it forms a barrier to ultraviolet rays, which can be harmful if overabsorbed.

Snakes do not always wait for the stratum corneum to become worn before growing a new one. For an adult snake to follow one sloughing with another within a few weeks is by no means unusual. Just why it does this is not known for certain; with captive snakes, skin shedding in rapid succession usually occurs after a snake has consumed large quantities of food following a period of fasting. As a rule, an adult snake sloughs three to four times a year, at intervals that are sometimes fairly regular, but often vary widely. Skin wounds can cause frequent sheddings, one following close upon another in order to hasten healing. Skin lesions, whether due to injury or disease, show marked improvement—sometimes disappearing completely—when the outer epidermis is renewed. But frequent shedding also occurs in snakes that show no sign of skin injury.

The more rapid a snake's metabolism, the more frequently it will shed; and generally, the higher the temperature, the more rapid its metabolism. There are a number of tropical snakes, however, such as pythons and boas, which are capable of regulating their metabolic rate regardless of temperature. Their metabolism does not necessarily become more rapid as temperature rises because by varying the secretion of certain hormones they can retard their physiological processes and estivate. During estivation shedding is either minimal or nonexistent. Snakes in temperate climates experience temperature-induced high metabolism only during very warm spells. On the other hand, they usually demonstrate a slowed metabolism after a large drop in temperature. When the temperature becomes low enough, they hibernate. Skin shedding does not occur during hibernation, and in the case of a snake that is preparing to slough when it enters hibernation, the process is halted by the prevailing low temperatures and will not recommence until warmer weather returns in the spring.

While its metabolism is dictated by

*An arboreal Central American green viper,* Bothrops lateralis, *begins to slough its outer epidermis. Getting the skin on the head to start peeling is the most difficult part of the process.*

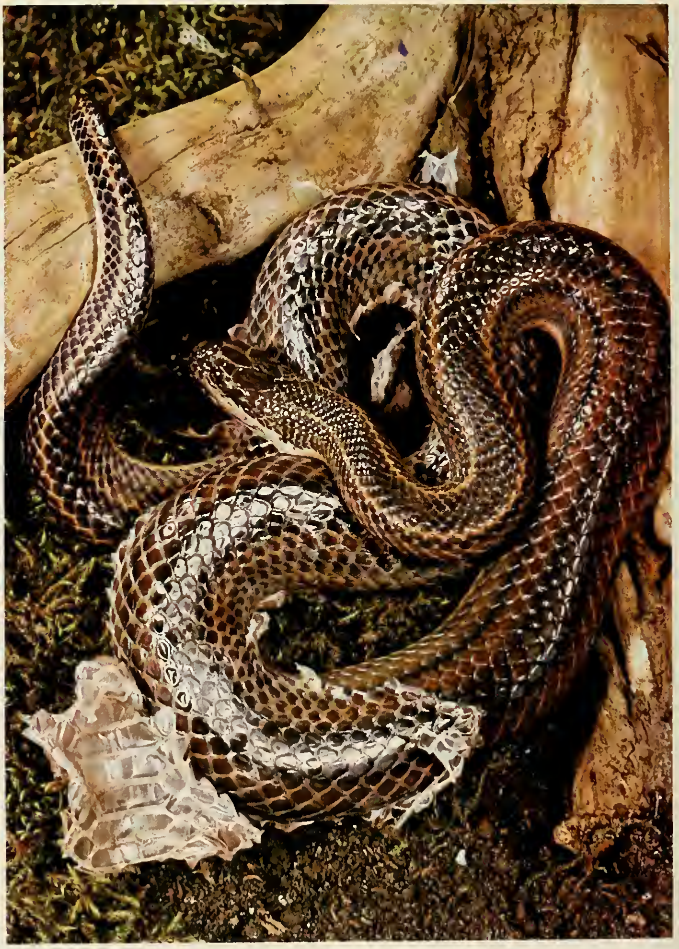
Sherman A. Minton

temperature and hormone secretion, a snake cannot operate at full capacity until there is a substantial intake of food. A snake that begins to feed after a lengthy fast usually eats ravenously. A sudden reawakening of appetite is also likely after shedding, and the rapid intake of a large quantity of food results in such an abrupt acceleration of the snake's metabolism that a second shedding of the skin follows a few weeks later.

Nearly forty years spent studying snakes has brought me to the conclusion that the major influence on the frequency of skin shedding is the amount of food consumed. A snake that feeds greedily sheds its skin more often than does an indifferent feeder. But the subsequent rapid growth in a snake that feeds readily is not the prime cause of frequent sheddings. An aged snake grows very little, if at all, yet it will shed more often when it is feeding well than when disinclined to eat. For example, an aged royal python in my possession, which measured 58 inches when captured, and which has grown scarcely at all in the seven years since then, will shed twice a year if it has fed well over a period of several months. But during fasting, the interval between one shedding and the next has been as long as eighteen months. Like most royal pythons, it is an erratic feeder and frequently fasts for long periods.

In most cases, a sudden disinterest in food signals that a snake is preparing to shed its skin. Gradually, colors dull and markings become less distinct. The ventral scales and the skin between the dorsal scales may take on a milky

*An oily secretion exuded by the underlying skin tissue aids in the removal of the stratum corneum. The old skin of this rainbow water snake is coming off in pieces as it crawls over some tree roots.*

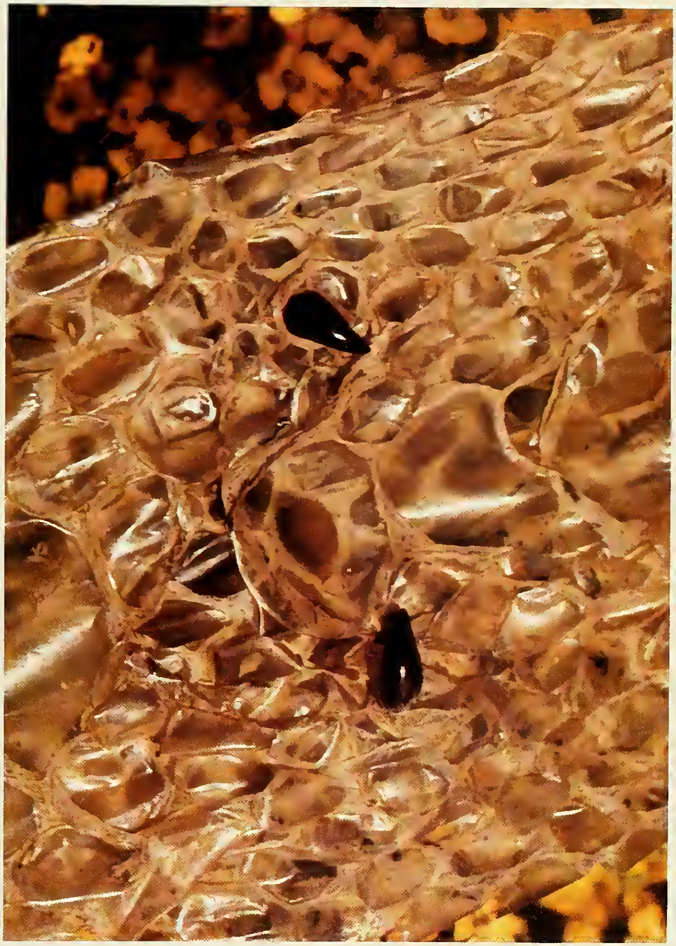


E.R. Degginger

gray color. But not all snake species exhibit this graying phase, and it is often difficult to determine whether they are preparing to shed until the eyes become obscured by a grayish white opacity. All snakes exhibit this symptom, and when its eyes begin to cloud over in this manner, a snake is said to be entering an "opaque." The eye shield's opaqueness is caused by a thickening of the outer layers of skin and occurs as the new stratum corneum starts to form beneath the old one. The thickening epidermis also obscures the colors and markings of the snake, most of which are in the deeper layers of skin. The Brazilian rainbow boa is one snake that does not become drab as ecdysis draws near; instead its beautiful reddish orange color is transformed to a striking silvery white. The length of time the eyes remain obscured varies by species; for most it lasts five to six days, although total opacity is only half that time.

Generally, a snake is largely inactive and prefers to remain hidden since it is particularly vulnerable to attack by other predators while its vision is impaired. A cool climate snake, however, will often emerge to bask in the sun if insufficiently warm in its hiding place. As a rule, a snake that is preparing to shed will not feed, although individuals vary, and some will continue to feed until the eyes become obscured. Others will feed immediately after the eyes have cleared and before the skin has been cast. But most will not feed for several days prior to entering the opaque stage and will only recommence feeding when the old skin has been completely removed.

*Claw casings can be seen on the freshly cast skin of a yellow anaconda. The claws, a feature common to pythons and boas, are located near the vents of the snakes.*



Leonard G. Appleby

*Overleaf: Most snakes become drab as ecdysis draws near, but the Brazilian rainbow boa is not one of them. This snake's reddish orange coloring is replaced by a silvery white at shedding time.*

Leonard G. Appleby

When the moment arrives for the skin to be cast, which occurs between two and five days after the eyes have cleared, the snake awakes from its torpor and becomes restless. To loosen the old skin, it rubs its nose and the sides of its jaws against rough surfaces. Some snakes yawn frequently, an action that sometimes causes the skin to break free from the edges of the mouth. Small snakes will often burrow just below the surface of loose soil and thus start the skin peeling. Normally, shedding begins at the head, and getting the skin to break free at this point often takes the snake longer than ridding itself of the whole skin.

Once it has started to peel, the old stratum corneum usually unfurls rapidly. Separation of the new epidermis from the old is assisted by a secretion exuded by the underlying layers of skin tissue. As the old skin comes away, the presence of this secretion, which also gives some snakes an oily appearance, is revealed by the moistness of the snake's body and the inside surface of the old skin. This sticky secretion causes particles of foreign matter to adhere to the skin that has been cast. Where there is adequate separation between the two layers of skin, removal of the outer one can be completed within ten to twenty minutes.

As the skin comes away from the head, the snake reduces its head rubbing and begins to push its way through dense vegetative growth, where available. The loosened skin catches on twigs and branches, which help to pull it free as the snake moves forward. Any narrow gap through which the snake can squeeze itself will assist in removing unwanted skin, and it is not unusual to find the cast skin of a snake draped in a forked tree branch. While such aids to shedding help to speed the process, they are not necessary. Once the skin is free of the head and forepart of the body, a snake is capable of removing it through muscular action involving alternate contraction and expansion of a small section of the body at a time. This not only loosens the skin, but also pushes it backward toward the tail. The muscular action is, however, only possible up to a point just anterior to the vent. The snake accomplishes removal of the skin covering the tail by moving forward and allowing the drag of the trailing skin to pull it free.

Nearly all snakes can, under favorable circumstances, shed the outer epidermis in one piece. This occurs commonly among the smaller species, but the considerable weight of the large pythons and boas often prevents them from shedding in one piece. Their skin often tears and is shed piecemeal. Many snakes require a certain degree of humidity to be able to achieve a perfect shed. Desert-dwelling snakes, however, and others accustomed to a fairly dry habitat, are able to remove the integument easily and completely no matter how dry their surroundings.

The cast skin possesses none of the colors of its former owner, but may show the markings quite distinctly. Nearly all cast skins are either transparent and colorless or semiopaque and a dirty brown. Depending on the species, some are very fine and delicate; others are coarse and rough. Pythons and boas, which have a pair of claws at the vent position, also cast the outer casing of the claws along with the skin, although these often become detached during shedding and are not always seen on the shed skin. On a perfectly cast skin every scale, including the eye shields, can be seen.

In all cases the cast skin is longer than the snake itself because the connecting skin tissue between the scales, which underlaps them, becomes unfolded and extended during shedding. But the amount by which the cast skin is longer than the snake depends largely on the skin's elasticity, and this in turn depends on the conditions in which it was removed. A skin cast in a very damp atmosphere will stretch considerably more than one that is shed under dry conditions. Consequently, the cast skin of a desert-dwelling snake may be only slightly longer than the snake itself, whereas that cast by a water snake in its natural habitat may be longer than the snake itself by as much as one-fifth the snake's length.

One of the snake's first actions after it has released itself from the unwanted skin is to take a drink of water, if possible. Many snakes not only stop feeding while the new stratum corneum is forming, but also do not drink. There is considerable loss of moisture through evaporation from the body during the actual casting of the skin, and this must be replaced.

Shedding is an important event in the life of a snake, for not only does it acquire a new and roomier integument, but also minor skin wounds are healed and unwelcome parasites such as mites are left behind with the shed skin that lies everted on the ground.☐

*A shedding snake will often squeeze through any available gap so that its loosened skin will snag on protuberances and come free as the snake moves forward. Loose tree bark can serve the purpose.*

mos Blank, National Audubon Society; Photo Researchers

# If Wittgenstein Had Been an Eskimo

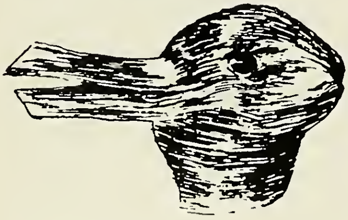
*Even for profound philosophers, literacy has its limitations*

**by Edmund Carpenter**

The philosopher Ludwig Wittgenstein and the art historian Ernst Gombrich contend that we cannot see both rabbit and duck in a single image simultaneously. Illusion, Gombrich says, consists in the conviction that there is only one way of interpreting the visual pattern in front of us. Although we may switch rapidly from rabbit to duck, we cannot experience alternative interpretations at the same time. A shape cannot be seen apart from its interpretation.

Discovering the rabbit in the duck produces, according to Wittgenstein, a surprise not produced by the recognition of either image alone.

Both men, famous for their analytical investigations, chose the same visual pun for intensive analysis and they agreed on its interpretation. Moreover, they invited their readers to play the game themselves and test their conclusions. But how do people from a different background, say Eskimos, perceive visual puns? Can they see the duck and rabbit simultaneously?


Drawing from nineteenth-century German jokebook

Visual punning is an ancient art. A carving from the Canadian Arctic, circa A.D. 1300, simultaneously represents a man in a hooded coat and a dog or, phrased another way, a dog-man, perhaps one popular in Eskimo tales.

I once showed Dali's *Paranoiac Face*, with its double image, to several Eskimos. Painting was alien to them, but visual punning was not; they showed a craftsman's appreciation of skillful work.

Eskimos love visual puns. So do Melanesians and so did the Aztecs. In our own culture, these double images were much favored by surrealists and perhaps have always and everywhere delighted children.

Visual puns vary greatly, but all share one characteristic: each line simultaneously serves two or more images. That is, several figures occupy one space or one figure plays several roles in a single space.

The sheer technical challenge of producing visual puns probably spurs punsters to great efforts. I have seen up to five images in one form. And that form was probably just one aspect of a multisensory pattern in which dance, music, navigation, poetry, and dreams commingled.

Literate man wants none of this. He not only fails to create visual puns but suspects the worst of those who do. Art critic René Crevel, commenting on Dali's puns, says, "It is by a frankly paranoiac process that it is possible to obtain a double image. . . ."

The trouble with this view is that psychotics don't produce double images. Nor do children, although they enjoy them. I say this with confidence because I've searched at length for visual puns in the art work of both and have yet to find one good example. Drawings by psychotics sometimes include what appear, at first, to be puns, but closer examination reveals more confusion than coherence. By contrast, Eskimo punsters demonstrate superb control of multiple perspective. "Art, being bartender," wrote Randall Jarrell, "is never drunk."

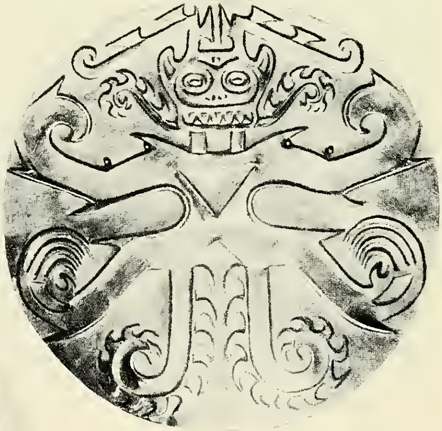
And puns, being art, are rarely accidental. Of course, the punster may deny his work. A Madison Avenue designer who produced an erotic pun called it an accident. So did the designer of a 1951 West German stamp commemorating Hans Böckler: inverted, Böckler became Stalin.

But visual puns don't just happen. They aren't the scribblings of children or madmen. They don't belong in philosophical seminars or psychology labs. And they are not gimmicks designed to surprise. They are deliberate works of art.

For years I regularly asked students to draw visual puns and keep diaries of their efforts. With rare exceptions, each student started with one image, then tried to superimpose a second image. The results, as art, were awful, and the diaries were records of frustration.

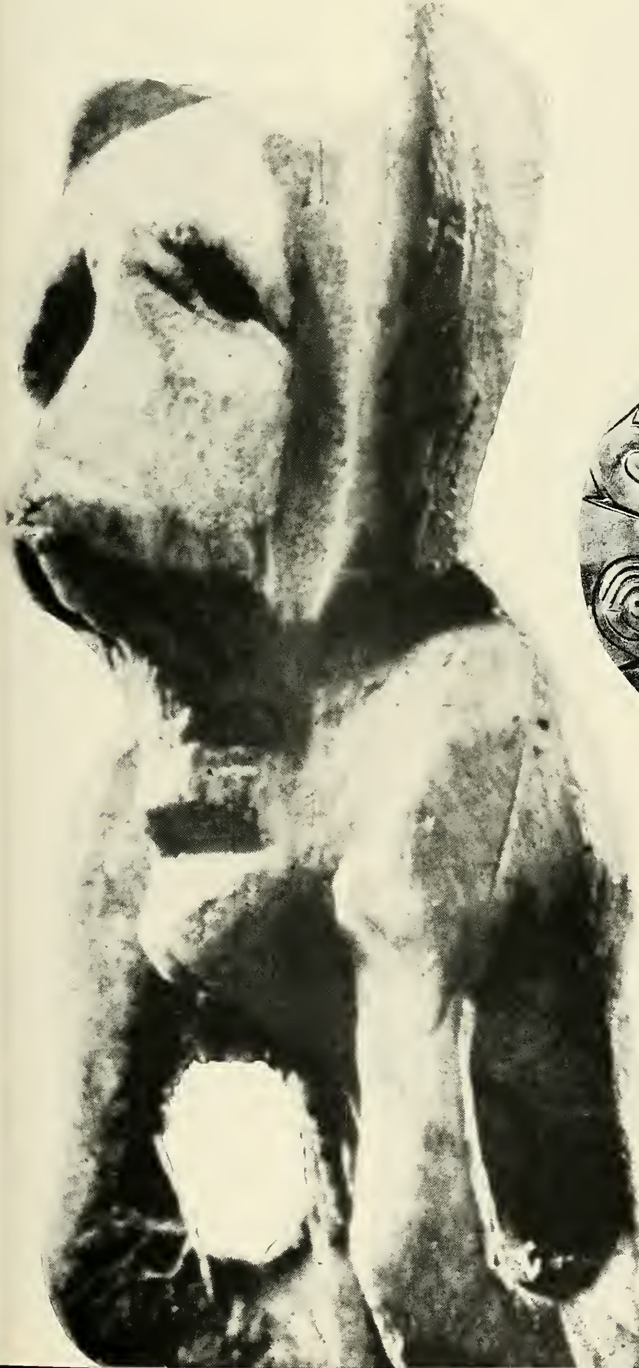
In contrast, an Eskimo carver, having "discovered" a pun in unworked ivory, releases it: the image steps forth in all its complexity. Or a pun may appear to a dreamer, who then executes its likeness.

Such puns are implosive, like the dreams or myths from which they come. An Eskimo myth may include both cause and effect, the way a missile's fuel is its engine and its engine is its fuel. Entire Eskimo societies are



*When inverted, a pre-Columbian gold plaque from Coclé, Panama, reveals a second head with a crown.*

University Museum, University of Pennsylvania



*A dog and a man can be visualized in this carved Late Dorset Eskimo figure, circa A.D. 1300, from Mill Island, south of Bassinland.*

National Museum of Canada

implosive: everybody is simultaneously involved with everybody. There is no isolated self and no elevation of sight over the other senses.

This emphasis on sight is literate man's mark and strength, but the other senses suffer correspondingly. If used at all, they are used like sight. All experience is translated into visual models. We say, "Let's see what we can hear."

The increasing number of native authors—voices from the inside—is one of the most interesting features of contemporary anthropology. These intruders into the visually oriented profession of anthropology are always writing about how things smell, taste, feel, sound: toes gripping roots along a slippery bank; peppery food burning the rectum; "he became aware of gentle heat playing on his right cheek, and a fine smoke teasing his nostrils; while on the left he heard an odd gurgling sound. . . ."

These inside reports, with their descriptions of sensory awareness and involvement, reveal how misleading the traditional, outside "observations" have been. My impression of much tribal art is that it should be embraced, all senses involved, not simply viewed. Putting it on display is like displaying an old, cuddly doll behind glass.

Not long ago, when some British children were asked, "What are the twelve loveliest things you know?" one boy answered:

The cold of ice cream.
The scrunch of dry leaves.
The feel of clean cloze.
Water running into a bath.
Cool wind on a hot day.
Climbing up a hill, looking down.
Hot-water bottle in bed.
Honey in you mouth.
Smell in a drug store.
Babies smiling.
The feeling inside when you sing.
Baby kittens.

A girl's list went like this:

Our dog's eyes.
Street lights on the river.
Wet stones.
The smell of rain.
An organ playing.
Red roofs in trees.
Smoke rising.
Rain on your cheeks.
The smell of cut grass.
Red velvet.
The smell of picnic teas.
The moon in clouds.

About 1900, Enos Mills, a mountain guide, became snow-blind in the Rockies at 12,000 feet. "My faculties," he reports, "were intensely awake." He could not use trails because of the depth of snow. Carrying a long staff, he set out on snowshoes to find the blaze marks on trees, which he had made on his forward journey. Making his way from tree to tree, he thrust an arm into the snow, feeling the bark of the trees until he discovered the marks of the blaze. He resorted to the trees for the points of the compass. He knew that the canyon walls facing south carried pines, while those facing north carried spruce. Keeping pines on his left, he traveled to the eastern side of the range. To check this, he examined lichens on low-lying boulders and moss encircling tree trunks, concluding that the area admitted light freely from all quarters. He shouted, noted from which direction the echoes came, their intensity and cross-replies, and concluded that he was going into the head of a deep forest-walled canyon. In the night a snowslide almost smothered him; enormous rocks and entangled branches made his progress more difficult. Suddenly he caught the scent of aspen smoke. Under favorable conditions a person with a keen sense of smell can detect burning aspen for several miles. Going forward into the wind, he emerged from the woods where the smoke was strongest and knew a cabin was near. In fear of passing it, he stopped to use his ears. As he stood listening, a little girl gently, curiously asked: "Are you going to stay here tonight?"

Children learn to separate their senses when they learn, in class, to read silently. Their legs twist, they bite their tongues, but with enormous effort they learn to fragment their senses, to turn on one at a time and keep the others in neutral. And so they are indoctrinated into that world where readers seek silent solitude, concert-goers close their eyes, and gallery guards warn, "Do not touch."

All this is alien to Eskimo experience. Once, with visibility zero, I traveled rapidly along a dangerous coastline, guided by an Eskimo who navigated by the feel of wind and smell of fog, by sounds of surf and nesting birds, and particularly by the feel of the pattern of waves and current against his buttocks.

With such interplay and interpenetration of senses, no single sense can be isolated. An Eskimo hunter who relied on sight alone would return empty-handed; a traveler who ignored odors and winds and sounds would soon be lost.

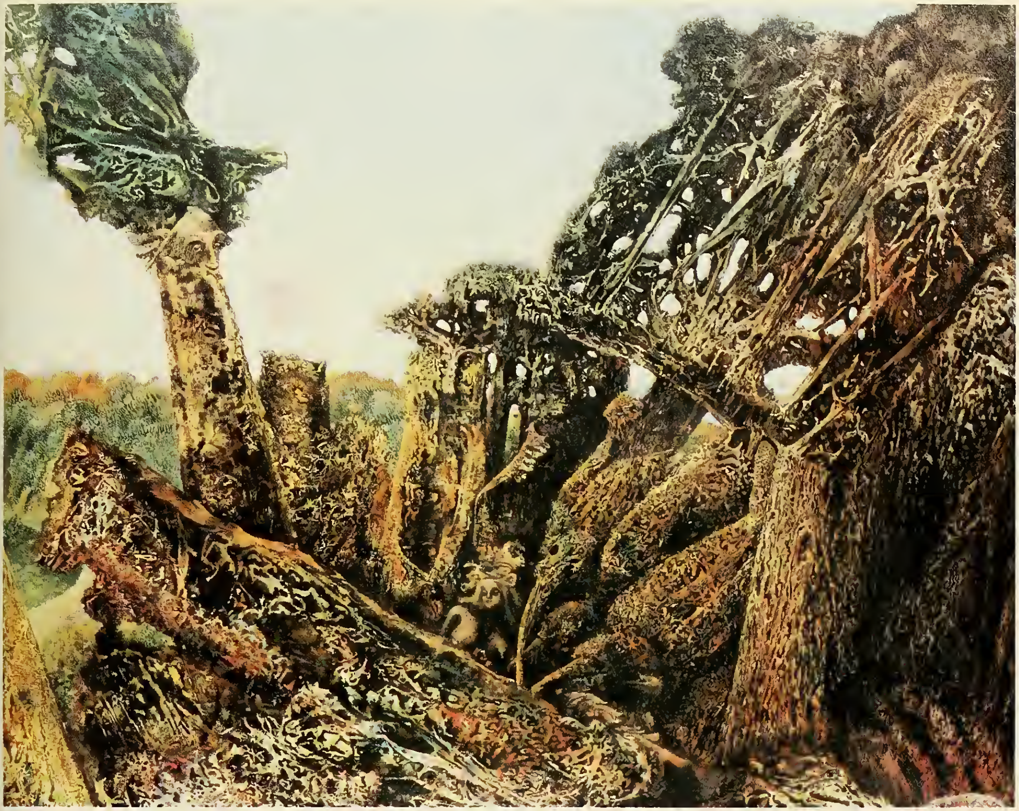
Recently, comparing paintings by blind children with those of seeing children, an experimenter found the two indistinguishable until the age of about six, at which point the seeing children moved in the direction of optical imagery.

Patients who have undergone throat surgery are forbidden to read, for there is a natural tendency for a reader to evoke absent sounds, and the throat muscles work silently as the reader scans the page.

Nothing was more alien to medievalism than silent reading. Reading was aloud, often as song, with gestures. Physicians prescribed reading as

Paranoiac Face, *by Salvador Dali, 1934/35*

Beyeler Gallery, Basel, Switzerland



*The surrealistic landscape of Max Ernst's* Totem and Taboo, *painted in 1941/42, contains bizarre faces, giant birds, and other hidden images.*

a form of exercise. Isolating one sense from all others calls for enormous training and self-control; it is probably never fully achieved. Test this yourself. Run water into the bath while switching the light on and off: the sound seems louder in the dark.

Phonetic writing translated multisensuous speech into one sense only. The peculiar effect of translating the many senses of the spoken word into the visual mode of writing was to abstract one sense from the cluster of the human senses.

The phonetic alphabet and all its derivatives stressed a one-thing-at-a-time analytic awareness in perception. This intensity of analysis was achieved at the price of forcing all else in the field of perception into the subliminal.

Literacy ushered man into the world of the divided senses. The value accorded the eye at the expense of all other senses destroyed the harmonic orchestration of the senses and led to emphasis upon the individual experience of the individual sense. It created a hierarchy of senses with sight highest, touch lowest. Aristotle, in the first sentence of *Metaphysics*, says, of all the senses, trust only the sense of sight. Plato went further: he regarded sight as the highest and touch as the lowest.

Sight is like no other sense: it favors detachment. I am *in* sound and smell; taste is *within* me; and touch presses *against* me. But with my eyes I become a detached observer, casting a hard eye on all experience.

Literate man takes literacy for granted, as if this sensory imbalance were a natural state. Yet the silent, immobile reader needs as much food as a miner, more sleep than a farmer, and clothing to conserve his energies. You cannot teach a naked man to read.

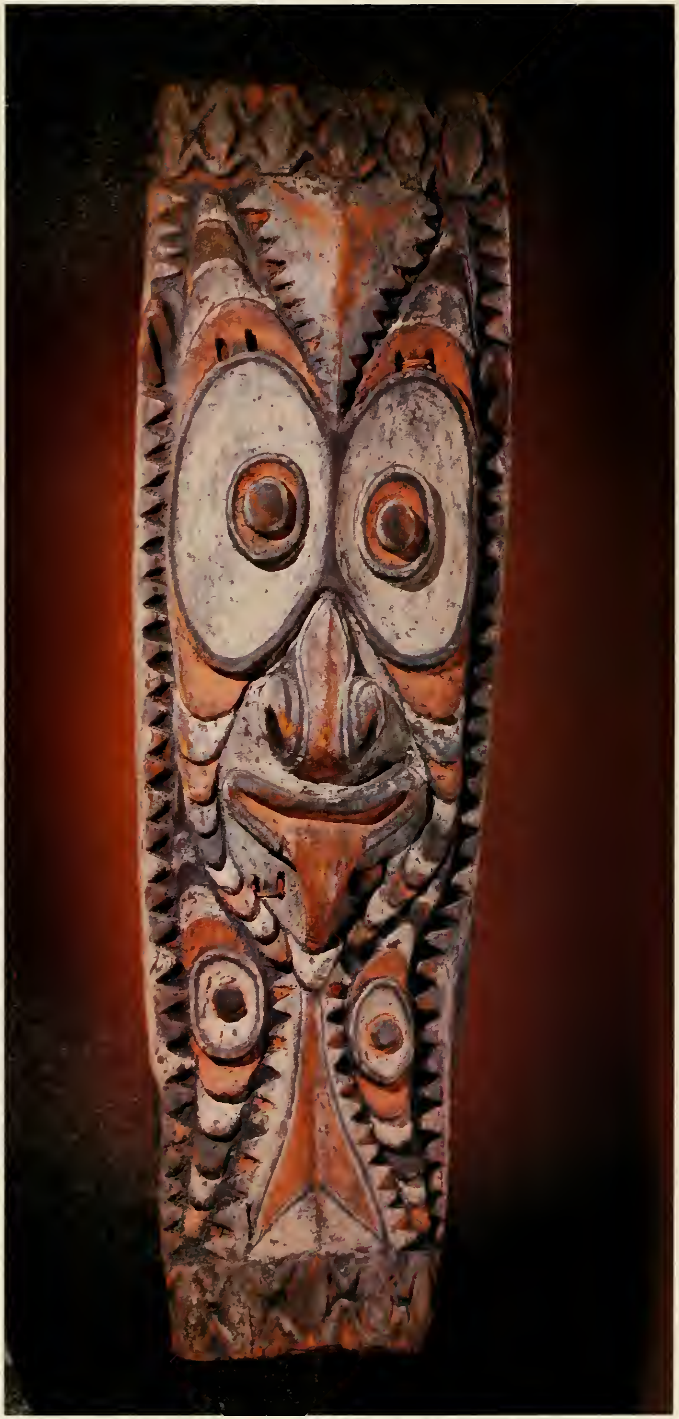
Literate man, observing a pun, first recognizes only the image rendered vertically relative to himself. The art historian Siegfried Giedion tells of a paleolithic carving of a horse that was on public display for decades. When the heavy stone was rolled outside to be photographed, everyone saw, for the first time, a second horse, inverted.

In both paleolithic and Eskimo art, images are not rendered in relation to the viewer. When handed a photograph, Eskimos examine it as it is handed to them, no matter how it is oriented. They look at maps from any direction, and if they understood English, I'm sure they would enjoy James Thurber's NOW NO SWIMS ON MON without turning it.

One may describe the alteration from duck to rabbit as a perception, as if the object had altered before one's eyes. But the picture doesn't change, just the observer's impression of it, point of view, emphasis upon one or-

Lee Boltin, Rockefeller Collection, Metropolitan Museum of A

Lee Boltin, Rockefeller Collection, Metropolitan Museum of Art



*Both an Iatmul shield, left, and a mask, right, from New Guinea contain double images of faces, which can be seen by inverting the objects.*

ganization over another. Suppose, however, the observer has no "point of view" or, more accurately, none resembling the private, delimiting one of literate man. Suppose the observer's art, language, and entire culture deny privacy and stress, instead, group awareness. Suppose, finally, no effort is made to suppress the "baser" senses or to make sight supreme.

Suppose all this and you have gone a long way toward describing Eskimos, who have no private point of view because they don't "view" life or conceive of an individual as a "point."

The artist M.C. Escher, whose visual puns have fascinated mathematicians, wrote:

> The border line between two adjacent shapes having a double function, the act of tracing such a line is a complicated business. On either side of it, simultaneously, a recognizability takes shape. But the human mind and eye cannot be busy with two things at the same moment and so there must be a quick and continuous jumping from one side to the other.

Does the Eskimo, like Escher, switch from one reading to another? Or can an Eskimo hold two disjunctive alternate readings simultaneously? We know that a literate person can recite a poem and meanwhile solve simple arithmetical problems. But while one is attended to, the other goes below some kind of threshold.

Other cultures seem to differ in the way they handle this kind of multiplicity of thought. Certain African groups can carry on five simultaneous rhythms: the melody and four percussion parts. All players often have their own downbeat. Three rhythms are common in preliterate music: melody, hand clapping, and foot tapping. This is extremely difficult for literates who "automatically" keep step to the music.

And the Eskimos, do they *actually* see the duck and rabbit simultaneously? Perhaps not, but they certainly see them faster, and in quite a different way, than Ludwig Wittgenstein. ☐

# Quasars Confirmed

*After more than a decade of controversy, the cosmological theory of these objects has been substantiated, establishing that quasars are the most distant and powerful sources of energy in the known universe*

According to the cosmological theory, the large red shifts found in the spectra of quasars are due to the expansion of the universe. In our universe, all the galaxies in space are rushing away from each other. The more distant a galaxy, the faster it is receding and hence the larger its observed red shift, which is caused by the Doppler effect. Since most observed quasars have larger red shifts than most known galaxies, the cosmological theory implies that the quasars are farther away than the galaxies.

Other theories have variously ascribed the red shifts of quasars to powerful gravitational force within each quasar; to a postulated violent expulsion of quasars from an explosion within our own Milky Way (or a neighboring galaxy); and to various new, unproved, and speculative physical effects. In all cases, these alternative theories state that quasars are less distant than indicated by the cosmological theory.

"Quasar" is an invented word, short for "quasi-stellar radio source." It stands for a celestial source of radio waves that resembles a star when seen through a visible-light telescope but that is *not* a star.

Most astronomers have accepted the cosmological theory of quasars ever since it was proposed in 1963. Like any other "established" theory, it has had a small number of vocal critics. In this case, however, the critics have included several of the world's most accomplished and distinguished astrophysicists.

The basic objection to the cosmological theory was raised because it implies that quasars are extremely powerful energy sources. If quasars are as far away as the theory tells us, then we can deduce that the radio emission of a typical bright quasar may be 1,000 times greater than the total of all forms of energy radiated by the hundreds of billions of stars and many nebulae of the Milky Way galaxy. Yet, such a quasar is about 30,000 times smaller than our galaxy. Further, some quasars emit even more energy in the form of infrared waves, visible light, and X-rays than they do as radio waves. To critics of the cosmological theory, it seemed unreasonable to suppose that so much power can be generated in so small an object.

To avoid this energy-production dilemma, some researchers decided that quasars must be much closer than indicated by the cosmological theory. If they are closer, then it follows that a quasar produces much less energy than estimated above. Also, the red shifts of quasars must then be produced by something other than the expansion of the universe.

Many astrophysicists believe that a quasar is a type of immense outburst in the center of a galaxy referred to as the "underlying galaxy." In that case, the light of the quasar would far exceed that of the underlying galaxy and it would be very hard to photograph the galaxy. Thus, the claimed existence of underlying galaxies would not contradict the fact that quasars generally look like isolated spots of light on telescopic photographs.

To check the cosmological theory, astronomers have searched for evidence of an association between galaxies and quasars. The two principal techniques have been to look for the underlying galaxies and to look for galaxies that occur near quasars.

Galaxies occur in two kinds of concentrations, strong ones called clusters and more diffuse ones called groups. All of the galaxies in a remote cluster or group are at roughly the same distance from the earth and thus have roughly the same red shifts. Clusters are such pronounced concentrations that they can be easily recognized on the *Palomar Observatory Sky Survey* (a standard atlas of deep space). Hence, many of the clusters that appear in the *Survey* have been cataloged and studied. They don't seem to contain quasars. But the weaker concentrations, or groups of galaxies, are hard to spot on the *Sky Survey* and most of them have not been cataloged. If quasars were found to occur in galaxy groups, and to have red shifts equal to those of the member galaxies, it would be clear that the quasar and galaxy red shifts are caused by the same process. Since galaxy red shifts are due to the expansion of the universe, such a discovery would prove the cosmological theory of quasars. Likewise, the detection of an underlying galaxy with the same red shift as its quasar would be strong evidence for this theory.

According to a 1973 report by a Hale Observatories astronomer, Jerome Kristian, underlying galaxies would most readily be detected as dim "fuzz" around the photographic images of the nearest quasars. Such fuzz has in fact been observed around several of the nearer quasars. This has been interpreted as evidence for the proposal that quasars are explosions in galaxies. Nevertheless, it did not confirm the cosmological theory, since it has not usually been possible to measure the red shift of the dim fuzz in the presence of the overwhelming light of the quasar. And even when fuzz is found around a quasar, that fuzz may not be an underlying galaxy but something else, for example, gas clouds ejected from the quasar.

Going one step further, if the fuzz is photographed well enough to show that it really is a galaxy, and if the red shifts of the fuzz and the quasar are measured and found to be equal, there may still be a loophole. Critics of the cosmological theory can claim, in such by Stephen P. Maran

a case, that what was photographed is just an unusual galaxy with a very bright nucleus and not a quasar at all. Thus, I have always felt that the hunt for underlying galaxies would not provide the most clear-cut proof of the cosmological theory.

Over the past decade, there have been several reports of red shift measurements for adjacent quasars and galaxies. In some cases, the quasar-galaxy pair were found to have nearly the same red shifts and those cases were claimed as evidence for the cosmological theory. In other cases, the adjacent galaxies and quasars were found to have widely different red shifts. This was taken to mean that quasar red shifts do not result from the same process as galaxy red shifts. Yet, for either conclusion to be drawn, the quasar and galaxy must actually be the same distance from the earth. The possibility always exists that, as seen from the earth, one object is in the foreground and the other far behind, so that they only seem to be next to each other. To resolve the issue, a careful survey of a statistically meaningful number of quasars was needed.

In July 1978, I was surprised to learn that a galaxy near the quasar 3C273 had been found to have the same red shift as the quasar. Although this might be just one more report of an isolated quasar-galaxy pair, an individual case with little statistical significance, I found the discovery remarkable because 3C273 is the brightest and best known of all quasars. It is actually visible in amateur astronomers' telescopes and its picture appears in nearly every modern textbook on astronomy. I had not imagined that the astronomers working on tests of the cosmological theory could have overlooked a galaxy near 3C273. For fifteen years, the largest telescopes in the world had been used to investigate quasars and espe-

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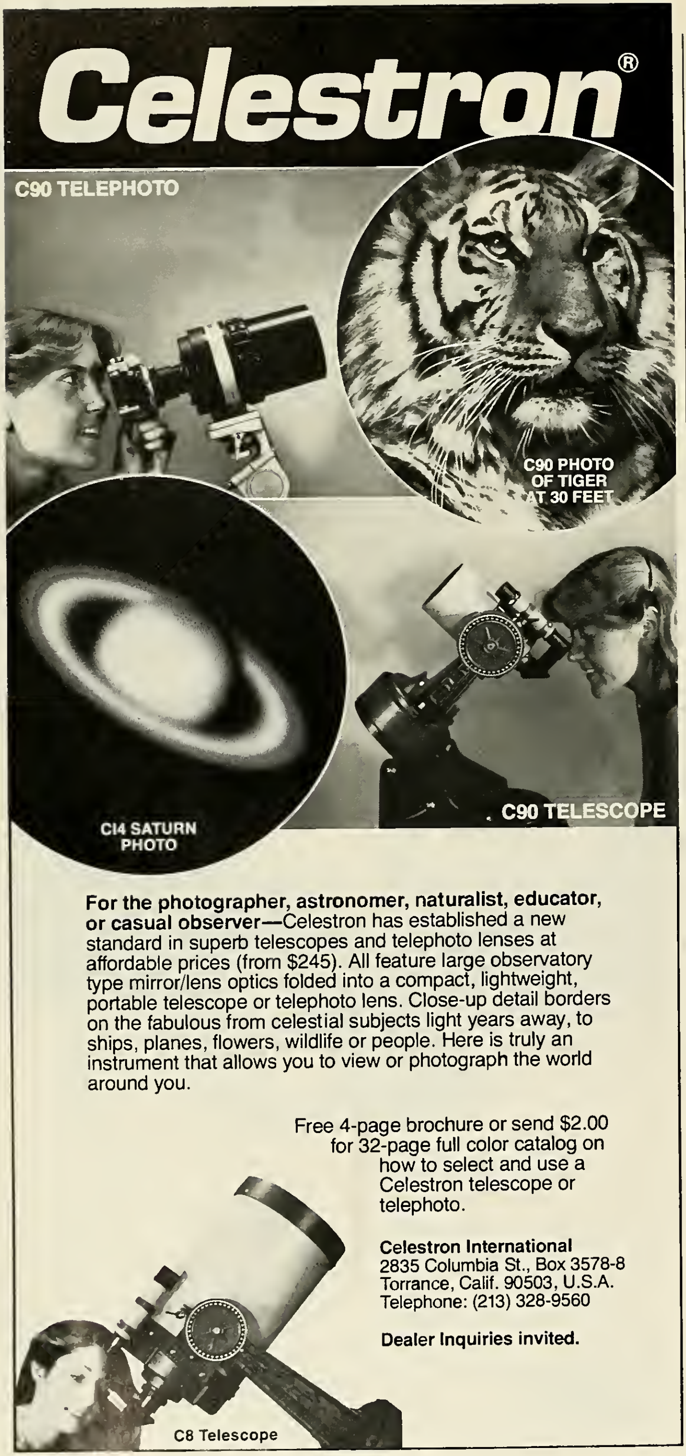

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cially the problem of their red shifts. But hindsight shows that many of the studies had a scatter-gun character or were even directed up blind alleys. The 3C273 finding, in contrast, was made by a young astronomer with a medium-sized telescope, as a byproduct of the first truly systematic investigation of the red shifts of galaxies near quasars.

The young astronomer was Alan Stockton of the Institute of Astronomy in Honolulu. Stockton had trained in quasar research at the University of Arizona in the late 1960s and has specialized in such studies ever since. His systematic investigation of galaxy red shifts appeared in the *Astrophysical Journal* in August 1978.

Stockton assumed that quasars *do* occur in groups of galaxies and that the cosmological theory of quasars is correct. He reasoned that a careful search of an area around each quasar, chosen so that the area is no greater than the size of a typical galaxy group, should reveal faint galaxies with the same red shifts as the quasars. The important thing was to use a fair number of quasars, chosen by a statistically valid means, and thereby avoid the criticism of the much-disputed, isolated cases reported by earlier researchers. Stockton selected twenty-seven quasars, all of them close enough to the earth (according to the cosmological theory interpretation of its red shift) so that galaxies in their vicinities would be visible on the *Palomar Observatory Sky Survey.* The quasars also had to be positioned in the sky so that they were observable with his telescope in Hawaii.

For each of the quasars, Stockton searched a circular area on the *Sky Survey*, with a radius of 45 arc seconds—about equal to the diameter of the planet Jupiter as seen from the earth. He also made new photographs, to insure that small, dim galaxies were not mistaken for stars or vice versa during the *Survey* inspection. Seventeen of the quasar areas were found to contain a total of twenty-nine galaxies, while ten were "empty." Some quasar areas contained up to three galaxies.

Stockton photographed the spectra of the galaxies with an 88-inch telescope atop Mauna Kea, on the island of Hawaii. He identified lines in the spectra of twenty-five of the twenty-nine galaxies and measured their red shifts. Of the twenty-five, thirteen (more than half) have red shifts corresponding to velocities of recession that are almost equal to those of the nearby

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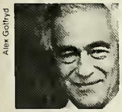

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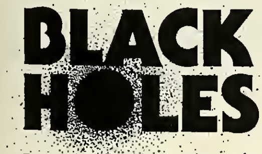

quasars. These thirteen galaxies are located in the areas surrounding eight of the quasars. All the other twelve galaxies differ in recession velocity from their "nearby" quasars, with a wide range of velocity difference: ten of the twelve have recession velocities that are over 15,000 kilometers per second (9,300 miles per second) smaller than those of the quasars, computed according to the cosmological theory. These much smaller velocities (red shifts) imply that the twelve galaxies are foreground objects.

If there were no relation between the quasars and the galaxies, there would be little or no clustering among the velocity differences that Stockton measured. But, as mentioned above, about half of the galaxies have nearly the same recession velocity, or red shift, as their adjacent quasars. (They agree to within 1,000 kilometers per second.) The odds are vanishingly small that this result is a statistical accident. In fact, Stockton calculates the odds at less than one chance in 1.5 million. The only reasonable interpretation of his red shift measurements is that a fair number of quasars occur in groups of galaxies and that they have the same red shifts as the member galaxies of the groups.

Stockton's investigation seems to prove the cosmological theory of quasars. His report appeared more than a year ago but no significant objection to it has so far been made. Yet, what he did was well within the capabilities of the major astronomical observatories of the world more than a decade ago. Last November I asked a leading authority on quasars why no one had carried out this project earlier. The answer, I was told, is that no one had worked hard enough at the problem. Many cleverly planned single observations had been made by others, but only Stockton had been willing to invest the time to make systematic spectroscopic observations of many very dim galaxies.

The confirmation of the cosmological theory of quasars was thus simply the happy outcome of long hours at the telescope. Twenty-five red shifts turned out to be more informative than any number of profound and imaginative astrophysical speculations.

*Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.*

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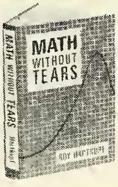

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# Sunken Treasure

Living Corals, by Douglas Faulkner and Richard Chesher. *Clarkson N. Potter, Inc., $45.00; 310 pp., illus.*

Tropical coral reefs inspire a fascination that has generated a large volume of publications, both scientific and popular. No single work could begin to adequately describe these massive and complex structures, and information tends to be scattered throughout a multitude of books and periodicals. Collecting these materials for study is routine for the worker in marine biology but beyond the resources of the general public. Guides and manuals have been compiled for identification of reef organisms; in the case of corals, these publications deal primarily with dead skeletons, and pictures and descriptions of the living forms are infrequent and scattered. The appearance of *Living Corals* would seem an important step toward filling a gap in the literature, although this does not seem to be the intent of the authors.

Diver-photographer Douglas Faulkner has presented a collection of 194 spectacular color photographs of reef corals. Seldom has the beauty of these organisms been so dramatically illustrated. Selection of the photographs to be included, as well as the conception of the text, was apparently based primarily on aesthetic considerations, which is at once both the strength and the weakness of the book. What results is a hard-cover slide show, intended to entertain and inspire rather than inform.

Certainly *Living Corals* has all the makings of a weighty tome: larger-than-life photographs of 117 species of living corals, covering 31 families of both hard and soft varieties; taxonomic verification by leading experts in the field; collection data and reference specimens deposited in the collections of the Smithsonian Institution. The book's review of the natural history of the reef is highly personal but generally informative and well written.

For these efforts the academically oriented reader can be thankful. As with extracting the pearl from the oyster, however, there is a lot of other material to get through in the process that may not be to one's taste. In his commentary, Faulkner argues that his photographs should stand alone as testimony to the wonder of the reef, with no running commentary to detract from visual delight, but the realities of the publishing world apparently forced a compromise of this ideal. The resultant union of art and science is a somewhat awkward marriage of convenience. Isolated in pristine magnificence, the photographs occupy the body of the book. Explanatory notes for each of the illustrations are grouped together in a separate section at the back. Reference to these "captions" is made by numbers positioned discreetly beside the photographs. This arrangement results in an annoying need for flipping pages back and forth between sections, a process made more difficult by the absence of an index and a not-too-robust binding that failed after the first day of this kind of treatment.

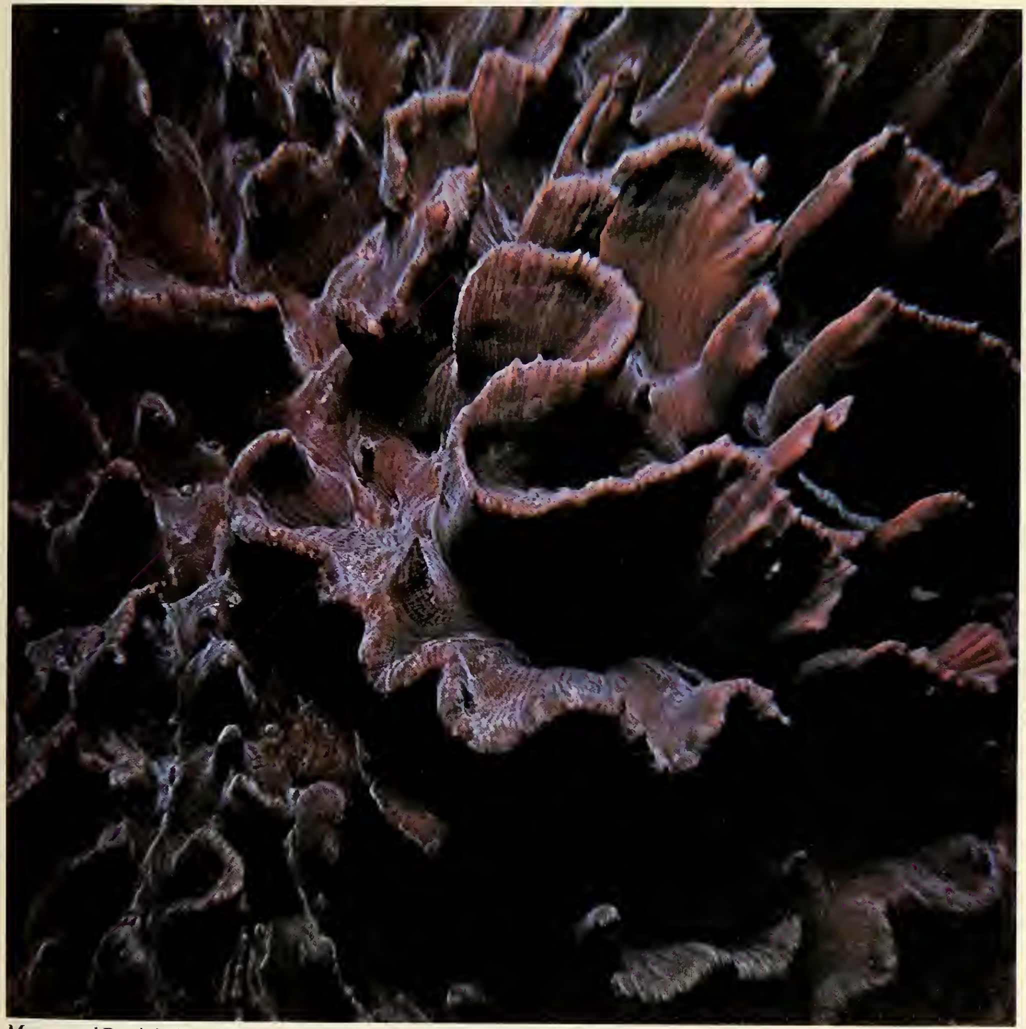
The scientific presence is further diluted in the notes, where information is offered in a haphazard fashion. The inquiring reader, seeking enlightenment about a particular life form discovered in a photograph, frequently finds little more than highly personal reminiscence or sentimental imagery, occasionally spiced up by a whimsical selection of common names invented by the author, such as, "She Loves Me Not Daisy Coral" and "Purple Polyped Plankton Eater Coral."

The rate of discovery in reef research usually outstrips the rate of publication, and much information is outdated before getting into print. Many of the concepts presented in this book have suffered this fate, especially in relation to reef geology and sea level. Although the Pacific's apparent sea level has generally fallen for the last 5,000 years, this is not true everywhere; impossible as it may seem, the opposite has occurred in the Indian Ocean and the Caribbean. Measurements of sea level change are not equal in all parts of the globe. The surface of the world ocean is perceived only in relation to its impingement upon land, even though it may be at a uniform position. The upward or downward movement of land masses affects the apparent rise or fall of sea level on a local scale.

A certain romanticism colors much of the presentation of reef ecology. The concept of the coral reef as a "superorganism" can create as many problems as it explains, erroneously setting the reef apart from other similarly complex and ancient ecosystems.

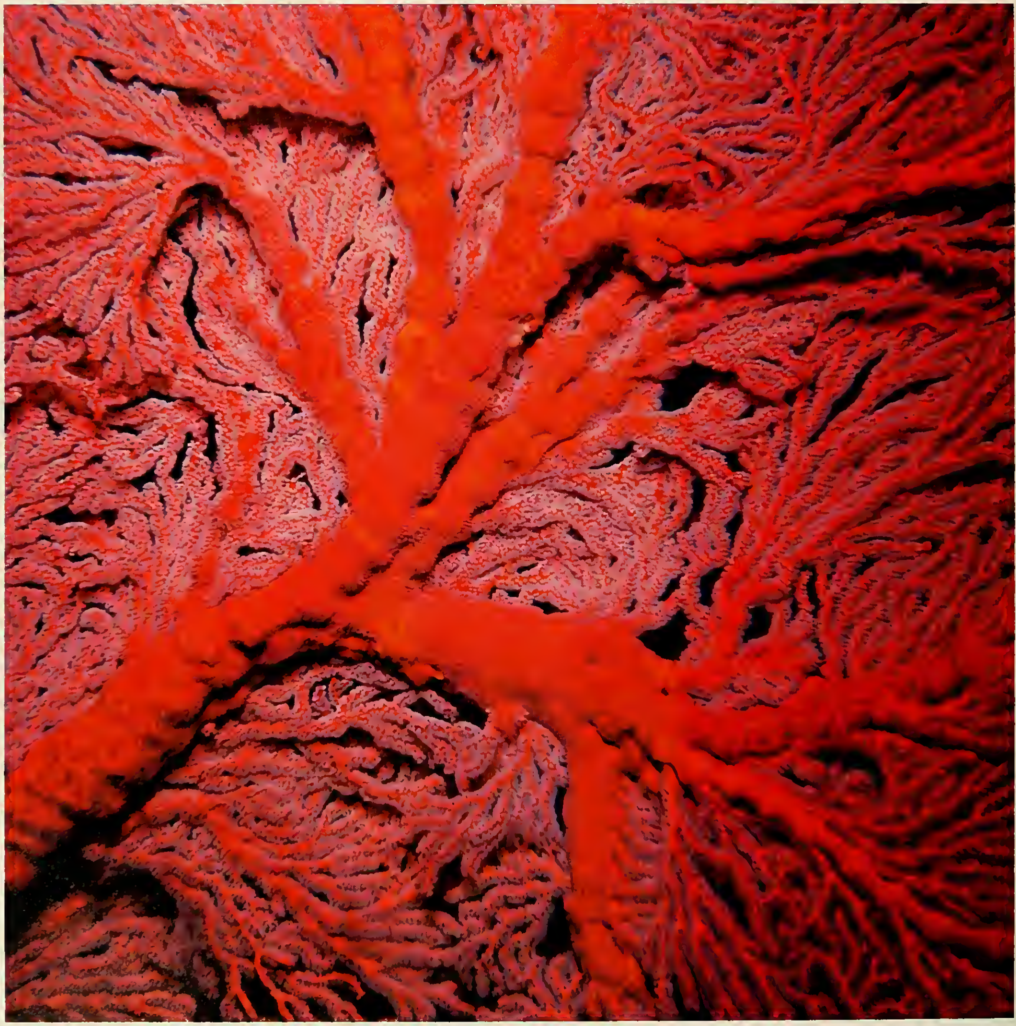
Localities of the specimens are identified by name only; no map is included. Let the reader note that "Belau," identified as the site of more than 80 percent of the pictures, is the native spelling for the Palau Islands, although reference to this nomenclature is not to be found in any map or gazetteer. Clarification of this matter is perhaps deliberately omitted. A desire for secrecy may have been engendered by the experience of the photographer, who upon returning to a favorite site, identified in a previous publication, found it stripped by collectors.

During his years of association with the underwater world of the coral reef, Douglas Faulkner gained a reverence for the life he observed there. It would be an admirable accomplishment if this feeling could be transmitted to a larger



*Maze coral* Pectinia lactuca

*Sea fan* Melithaea squamata *feeding, below, and contracted, right.*



*Tube coral* Dendrophyllia gracilis

audience, so that the general public might be equally impressed by the beauty and complexity of this portion of the environment, so often threatened by human incursion. However, this endeavor is not promoted by embroidering the obvious beauty, so effectively captured on film, with the kind of "plastic-flowery" prose favored by both authors. Consider this description of *Symphyllia recta*, the symphony coral (it has orchestrated movements): "The psychedelic concert of light on pattern is magical. Mesmerized by the pendulum tick of a metronome, I stare at a white mouse, pink nose twitching, scurrying along a cheese white line." This sounds less like a representation of any reef organism than the effects of nitrogen narcosis. Straightforward, well-crafted description would be a much more effective extension of the visual presentation.

Unfortunately, this opportunity to produce a valuable reference on the corals has not been fully realized. These days it is a rare marine biologist who does not dive and photograph, and having this collection for comparison is certainly helpful, as far as it goes. However, major elements of the fauna have been omitted, probably for lack of a sufficiently ravishing photograph. The Atlantic coral community has been especially shortchanged.

An unwieldy degree of randomness already exists in the literature and any effort to organize it should be welcomed. *Living Corals* has the raw material for a start in that direction.

*Walter H. Adey, a curator in the Department of Paleobiology at the Smithsonian Institution, has spent the past decade studying tropical reefs in the Caribbean.*

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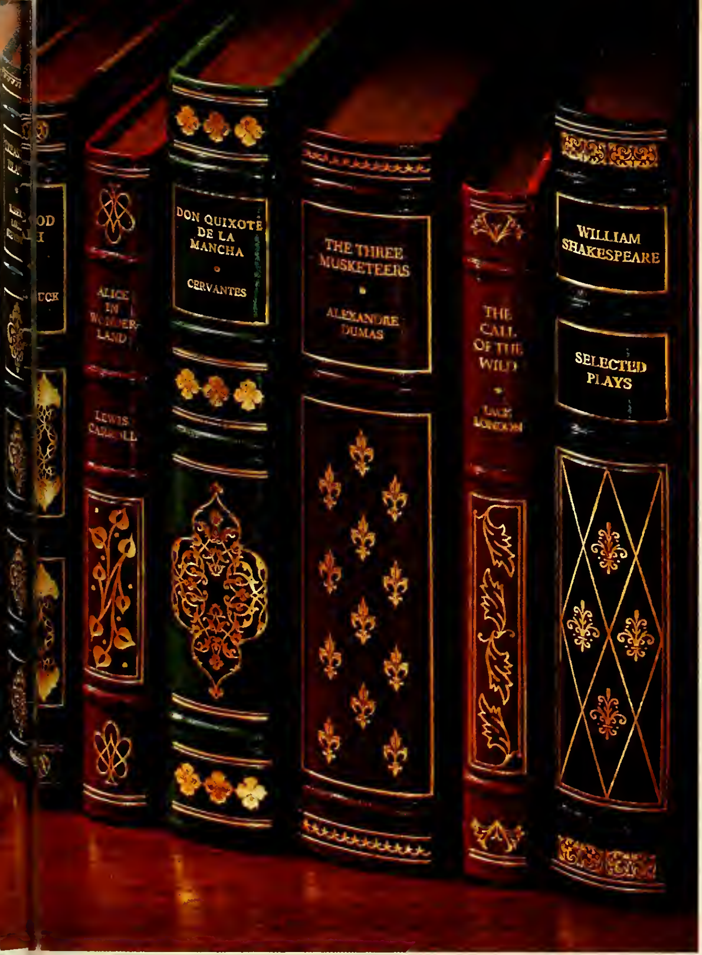

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Box numbers, telephone numbers, and hyphenated words count as two words; abbreviations and zip codes as one word each. All states are shown in two-letter code followed by zip, then telephone (with area code), if desired. Occasionally, slight editing is required for clarity. Thank you!

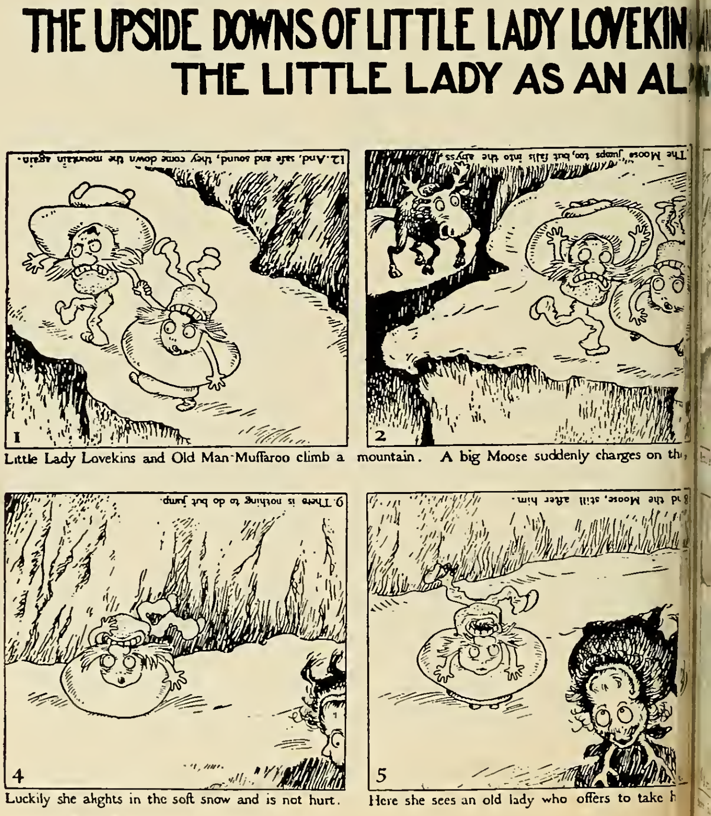
# Additional Reading

**Brown Hyenas** (p. 44)

Since 1972 a long-term study has been under way of the limiting factors for the southern Kalahari's endangered brown hyena population. M.G.L. Mills, a leading contributor to this study, summarizes some of his work in "Foraging Behaviour of the Brown Hyaena (*Hyaena brunnea* Thunberg, 1820) in the Southern Kalahari" (*Zeitschrift für Tierpsychologie*, vol. 48, 1978, pp. 113–41), which is also a guide to some current literature on brown hyenas. Two other papers are J. D. Skinner's "Ecology of the Brown Hyaena (*Hyaena brunnea*) in the Transvaal with a Distribution Map for Southern Africa" (*South African Journal of Science*, vol. 72, 1976, pp. 262–69) and "The Diet of the Brown Hyaena (*Hyaena brunnea*) in the Southern Kalahari" (*Koedoe*, vol. 21, 1978, pp. 125–49), by M.G.L. Mills and M.E.J. Mills. *Hyaena*, by Hans Kruuk (New York: Oxford University Press, 1975), contains many black-and-white photographs. While mainly about foraging, hunting, competition, and social behavior of the spotted hyena, the book includes comparisons with the brown hyena. A more detailed study of the spotted hyena, written by the same author, is *The Spotted Hyena: A Study of Predation and Social Behavior* (Chicago: University of Chicago Press, 1972).

**Water Bugs** (p. 56)

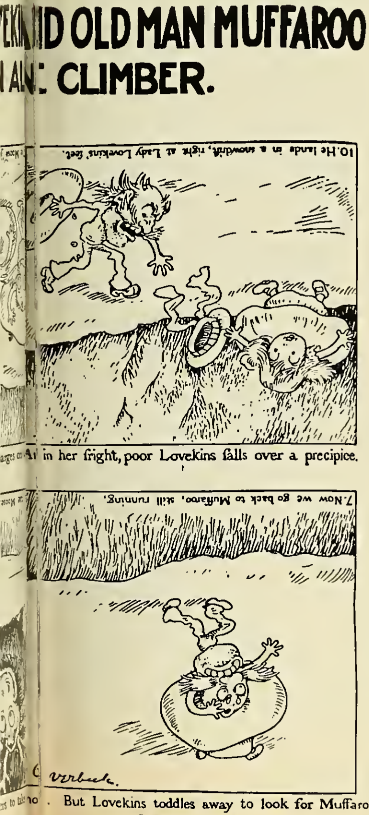
Robert Smith's most recent papers on the reproductive behavior of giant water bugs include "Repeated Copulation and Sperm Precedence: Paternity Assurance for a Male Brooding Water Bug" (*Science*, vol. 205, 1979, pp. 1029–31) and "Paternity Assurance and Altered Roles in the Mating Behaviour of a Giant Water Bug, *Abedus*


THE UPSIDE DOWNS OF LITTLE LADY LOVEKIN
THE LITTLE LADY AS AN AL
12. And, safe and sound, they come down the mountain again.
1
The Moose jumps too, but falls into the abyss
2
Little Lady Lovekins and Old Man Muffaroo climb a mountain. A big Moose suddenly charges on th
6. There is nothing to do but jump.
4
Luckily she alights in the soft snow and is not hurt.
the Moose, still after him.
5
Here she sees an old lady who offers to take h

From *The Incredible Upside-Downs of Gustave Verbeek* *herberti*'' (*Animal Behaviour*, vol. 27, 1979, pp. 716–25). Robert and Janice Matthews's *Insect Behavior* (New York: John Wiley and Sons, 1978) provides entertaining and informative accounts of reproductive behavior in a variety of insect species, and *Animal Behavior: An Evolutionary Approach*, second edition, by John Alcock (Sunderland: Sinauer Associates, 1979), draws examples of behavioral principles from the entire animal kingdom. *Sex, Evolution, and Behavior: Adaptations for Reproduction*, by Martin Daly and Margo Wilson (North Scituate: Duxbury Press, 1978), discusses the evolutionary causes of sexual behavior.

### Snake Skins (p. 64)

Skin shedding in amphibians and reptiles is discussed in *The Natural History of North American Amphibians and Reptiles*, by James A. Oliver (New York: D. Van Nostrand Co., 1955). Angus D'A. Bellairs refers to shedding throughout his *Reptiles* (Atlantic Highlands: Humanities Press, 1975) and also in *The Life of Reptiles*, volume two (New York: Universe Books, 1970). *All about Snakes*, by Bessie M. Hecht (New York: Random House, 1956), is a children's book on snakes that discusses and illustrates snakes shedding their skin. A technical paper with further references is ''Histological Changes in the Epidermis of Snakes during the Sloughing Cycle,'' by P.F.A. Maderson (*Journal of Zoology*, vol. 146, no. 1, pp. 98–113).


D OLD MAN MUFFAROO
CLIMBER.
10.He lands in a snowdrift, right at Lady Lovekins feet.
in her fright, poor Lovekins falls over a precipice.
7.Now we go back to Muffaroo, still running.
Verbeek
But Lovekins toddles away to look for Muffaroo.

Gustave Verbeek in the *New York Herald*, c. 1904

### Visual Puns (p. 72)

Ernst Hans Josef Gombrich has written numerous books on art, perception, and illusion. Of particular relevance are *Art and Illusion: A Study in the Psychology of Pictorial Representation*, second edition (Princeton: Princeton University Press, 1961) and *The Story of Art* (New York: E. P. Dutton and Co., 1978). His *Illusion in Nature and Art*, coedited with R. L. Gregory (New York: Charles Scribner's Sons, 1973), has six chapters by different authors, with discussions of the science and philosophy of illusion in art and nature, and many illustrations and photographs. Ludwig Wittgenstein's elegant, influential *Tractatus Logico-Philosophicus* (Atlantic Highlands: Humanities Press, 1972) represents his early linguistic philosophy and relates logic and language in his picture theory of language. Norwood Russel Hanson discusses philosophical aspects of research and discovery and argues that the discovery of plausible scientific hypotheses is a rational procedure in his *Patterns of Discovery: An Enquiry into the Conceptual Foundations of Science* (New York: Cambridge University Press, 1969). The book includes many examples of optical illusions. An article from the November 1972 issue of *Scientific American*, ''Pictorial Perception and Culture,'' by Jan B. Deregowski, illustrates how people of different cultures perceive pictures differently. This article can also be found in *Image, Object, and Illusion: Readings from Scientific American*, with introductions by Richard Held (San Francisco: W. H. Freeman and Co., 1974).

*Katharine D' Agosta*

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# Celestial Events

### by Thomas D. Nicholson

**Sun and Moon** The sun moves through the stars of Capricornus in early February, enters Aquarius about midmonth, and Pisces about March 12. On February 16, a solar eclipse occurs: total in a path crossing equatorial Africa, India, and China; partial over a wide area of the rest of Africa and Asia; but not visible in North America.

The moon is just past full on February 1, reaches last-quarter on the 9th, becomes new on the 16th, and first-quarter on the 22nd. Full moon occurs again on March 1, last-quarter on the 9th, and new moon on the 16th. During February, the moon occults (covers) Regulus twice, on the 2nd and the 29th; Jupiter on the 3rd; Saturn on the 4th; and Aldebaran on the 23rd; but no occultations will be observed from North America. Apogee moon (farthest from the earth) occurs on February 4 and March 3. Perigee (nearest the earth) occurs on February 17 and March 16, both shortly after the new moon, which will enhance the effects of the spring tides each time.

**Stars and Planets** Bright planets are well located on February and March evenings. Venus appears in the west during early twilight, brightening, appearing higher, and remaining progressively later during both months. Mercury also makes a two-week appearance in the evening twilight beginning about mid-February, when it goes through a favorable easterly (evening) elongation. The best show occurs a bit later at night, however, when Jupiter, Mars, and Saturn follow Leo up the sky. The leader of the group is Regulus, the brightest star in Leo. Close behind are Jupiter and Mars, both far brighter than Regulus. Mars is about half as bright as Jupiter and a bit more yellow. Last to rise and move across the sky is Saturn, just a little brighter than Regulus. From February 1 through 4 and again from the 29th until March 3, the moon will move past these objects. For Southern Hemisphere observers, the moon will be so close that it covers Regulus, Jupiter, and Saturn in turn.

February 1–4: Watch the moon slide past Regulus, Jupiter, Mars, and Saturn. It is closest to Regulus on the night of the 1st, to Jupiter on the 2nd, to Mars on the 3rd, and to Saturn on the 4th.

February 17: Perigee moon will bring strong tides this afternoon and tonight. Binoculars may help you find Mercury, a bright, starlike object to the right of the crescent moon during evening twilight.

February 18–19: Venus is near the crescent moon on both nights. Mercury is at greatest easterly (evening) elongation on the 19th.

February 22–23: The star near the moon is Aldebaran, in Taurus.

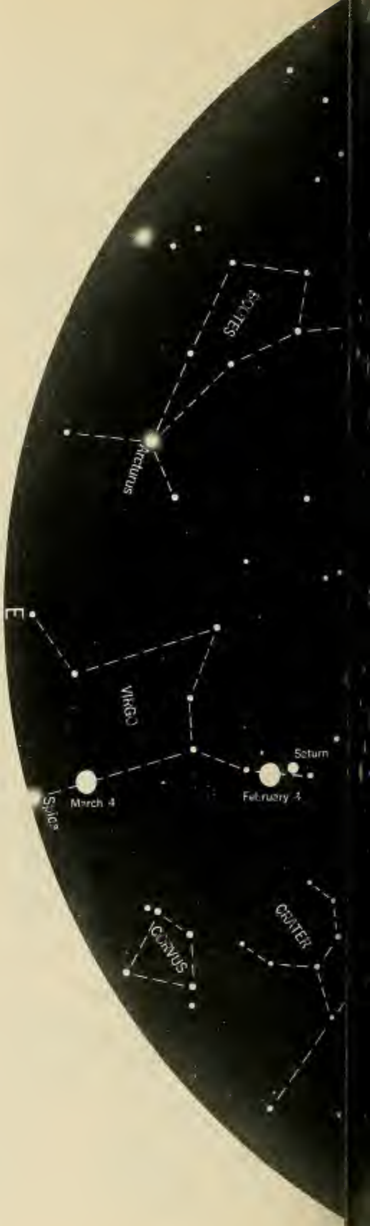
February 24–26: Jupiter is opposite the sun on the 24th, Mars on the 25th, and both become evening stars. Mars is nearest the earth on the 26th, about 62,962,000 miles distant. This is almost double its distance at a favorable opposition, when Mars becomes brighter than Jupiter.

February 29–March 3: The moon again moves past Regulus, Jupiter, Mars, and Saturn on successive days. Note, however, how the positions of the planets have changed from early February.

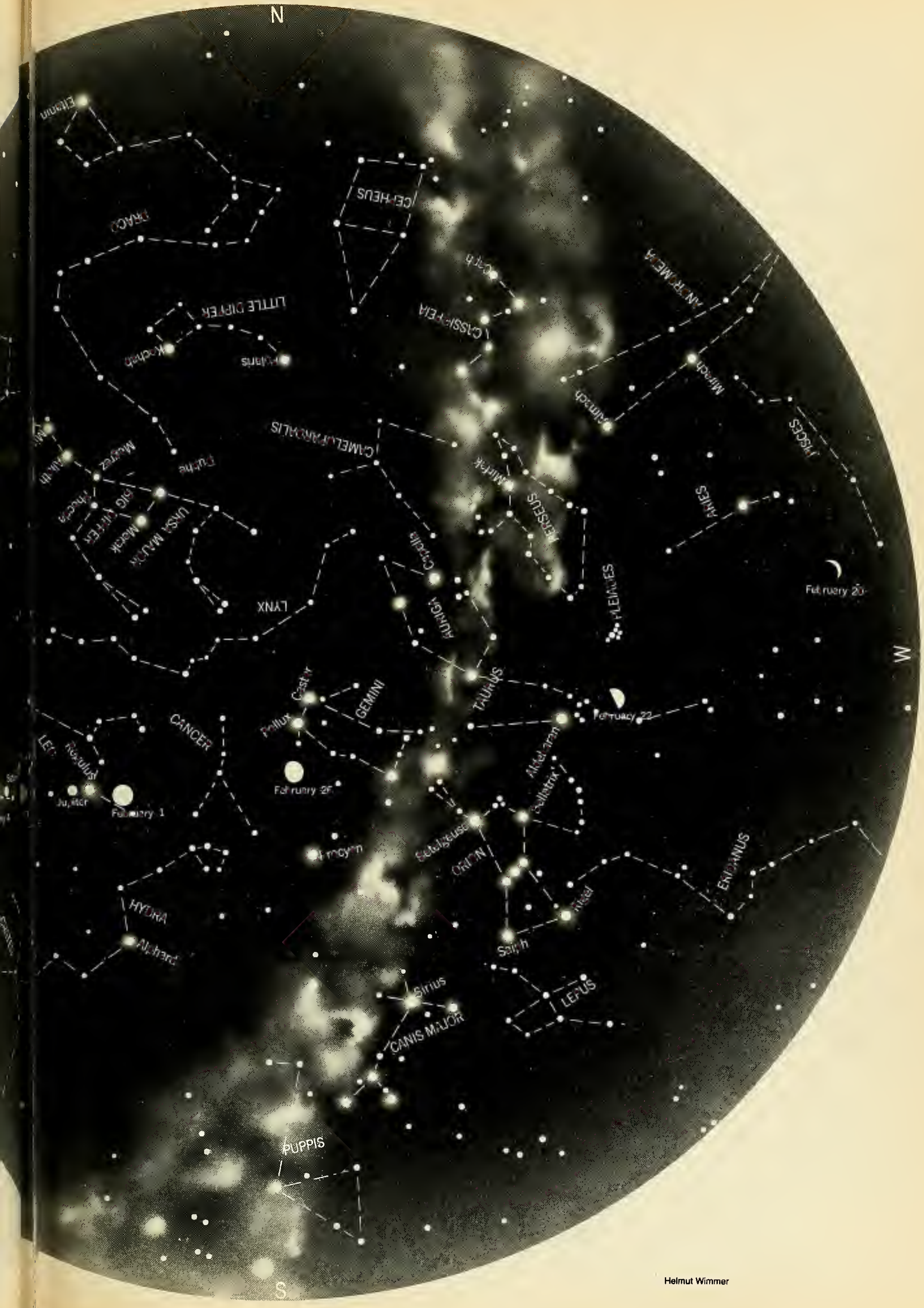
March 6: Mercury is at inferior conjunction, passing between the earth and the sun and entering the morning sky.

March 13: Saturn is at opposition from the sun and becomes an evening star, joining Jupiter and Mars. All three planets are now above the horizon at sunset and set before sunrise.

March 16: Perigee moon comes only two hours past the new moon, and will cause exceptionally strong tides on this and the following date.



★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:10 P.M. on February 1; 10:15 P.M. on February 15; 9:20 P.M. on February 29; and 8:25 P.M. on March 15; but it can also be used for an hour before and after those times.


N
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LEO
Regulus
Aldebaran
February 26
Jupiter
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Bellatrix
Betelgeuse
ERIDANUS
Procyon
ORION
HYDRA
Rigel
Saiph
Alphard
Sirius
LEPUS
CANIS MAJOR
PUPPIS
S

Helmut Wimmer

# At the American Museum

*A curator solves homicide and missing persons cases and may be on the track of the oldest missing person of them all*

In the early 1950s, an anthropologist at the American Museum of Natural History received a telephone call from the New York City Medical Examiner's Office. They were working on a difficult missing person case and needed his expertise. Would he be kind enough to help them out?

Most Museum scientists would have been astonished to receive such a call, but for anthropologist Harry Shapiro it was all in a day's work. Since joining the Museum's staff in 1926, he had helped the police solve dozens of homicide and missing persons cases.

This particular case, the most difficult he had worked on up to that time, concerned a little girl in the South Bronx. For three days after her disappearance, the residents of the apartment building in which she lived noticed excessive heat coming from the coal-burning furnace. The police had reason to suspect that the janitor of the building had murdered the girl, so they shut down the furnace and sifted through the ashes for bones. Because the building's garbage was also burned in the furnace, the police recovered five ashcanfuls of tiny, charred bone fragments.

"They wanted me to go through the barrels," says Shapiro, "and identify any human bones. I spent days and days looking at the fragments. Of course, most of them were just bones from the dinner table. Many were impossible to identify. Finally, I found three that were undoubtably human: a fragment of the rim of the orbit [the eye socket], a finger bone, and a fragment of the pelvis. From these I was able to deduce that the person had been a young girl, perhaps ten years of age. It was enough to convict the janitor of murder."

Shapiro studied physical anthropology under Earnest Hooton at Harvard and learned to draw a variety of conclusions from human bones. By examining a skeleton, he can deduce such things as the person's sex, age, weight, height, and race. As a curator at the Museum, Shapiro has studied the genetics of diverse populations, including the descendants of the mutineers of the H.M.S. *Bounty* on Pitcairn Island, the peoples of Tahiti and the Marquesas, and the Jewish people.

He had been at the Museum only a few years when he received his first call from a despairing medical examiner. The case involved a complete skeleton that Shapiro identified with ease.

"That started it," he recalls. "Whenever they ran into human material, they would call me up." In this way, almost by accident, Shapiro became involved in the practice of forensic anthropology. During World War II, at the request of the U.S. government, he put together a set of guidelines and procedures for identifying the unknown dead. Particularly difficult cases were shipped to the Brooklyn Navy Yard, and a limousine was

**Discovery Tours**

Thirty-four Discovery Tour participants are now taking a 600-mile cruise up the Nile River, accompanied by scientists and lecturers from the American Museum of Natural History. They are visiting the temples and tombs of the past and exploring the culture of Egypt today. C. Hackforth-Jones, an Egyptologist, Niles Eldredge, a paleontologist, and John Farrand, an ornithologist, are sharing their knowledge with tour members. Their lectures range in subject from the composition of building stones and the symbolic use of local wildlife in ancient Egypt to modern Egyptian history and culture.

An identical cruise up the Nile will depart on October 19, 1980. Other Museum-sponsored cruises and trips will explore the British Isles, Mexico, Maya Mesoamerica, Morocco, Mongolia, Alaska, New Guinea, and China. For itineraries and further travel information contact Discovery Tours at the Museum.

**Element 79**

*Gold!* is the topic of this month's members' program on Wednesday, February 20, at 7:30 P.M. in the Auditorium. George Harlow, a curator in the Department of Mineral Sciences and consultant for the *It's Gold* exhibition at the Museum, will show slides and a film and discuss the history, characteristics, and uses of gold. He will explore such topics as how gold forms and where it is found and will recount some of the legends and myths surrounding this coveted metal. The free program is open only to members of the Museum.

**Old New York**

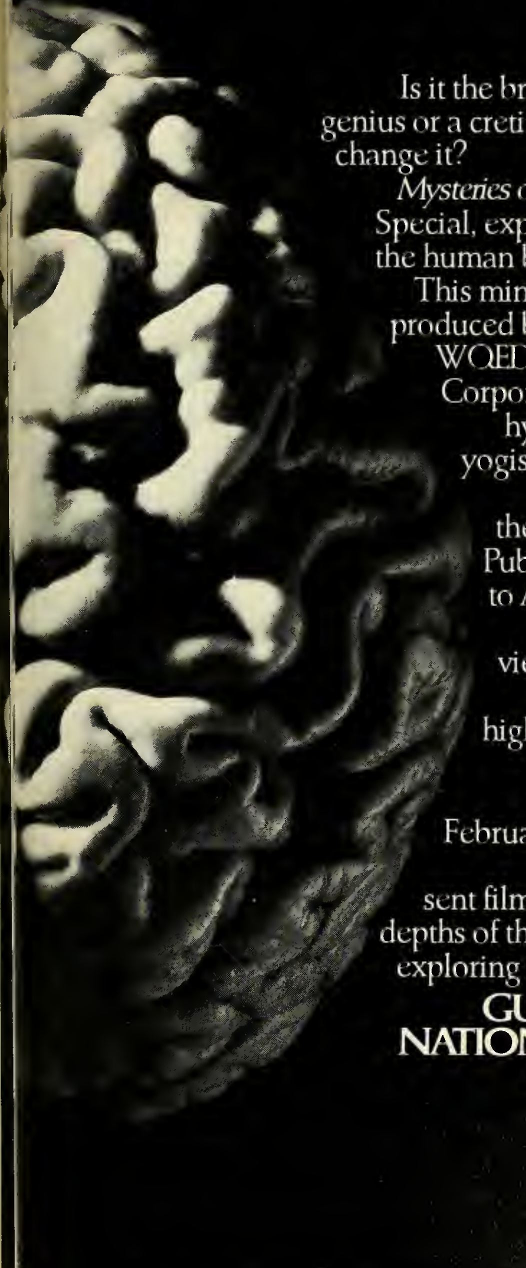
On Saturday, February 2, the Museum, in cooperation with the Archaeological Institute of America, will present an all-day symposium entitled *The Archeology of New York City*. The symposium will involve panel discussions with slide-illustrated papers. Participants include Bert Salwen, chairman and professor of anthropology at New York University, Nan Rothschild, professor of anthropology at Hunter College, and Robert Schuyler, professor of historic anthropology, University of Pennsylvania. The symposium will last from 10:00 A.M. to 4:45 P.M. in the Auditorium and is open to all Museum visitors. There is no admission charge.

**Kora Concert**

In celebration of Black History Month, Alhaji Bai Konte and Dembo Konte will present a musical interpretation of African folklore on Sunday, February 17, at 2:00 P.M. in the Auditorium. The program is free to Museum visitors. Bai Konte and his son Dembo will play the *kora*, a 21-stringed instrument of West Africa, which sounds like a cross between a guitar and harpsichord. The *kora* is the "KO" that helped to reunite the Kinte and Haley family branches of "Roots" fame. The Kontes are oral historians and balladeers, called *griots*, who keep alive the traditions and genealogies of the Mandinka people of West Africa. The program is sponsored by the Museum's Department of Education.

**Body Language**

Slim Goodbody will present the February members' family program on Sunday, February 24, at 2:00 P.M. in the Auditorium. Sporting his "body suit," with its drawings of internal organs, he will regale children with facts and stories about the human body—how it works and how to make it work better. The program is free to members; nonmembers may purchase tickets for $2.50 at the door.



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ered in China, nothing approaching the completeness of the first bones has ever been found.

Shapiro was a graduate student when the fossils were unearthed in the 1920s. Early hominid fossils were rare then, and he recalls that the discovery made a sensation. Later, in 1931, while doing research in China, he met Davidson Black, who was working with the fossils at Peking Union Medical College. Black let Shapiro examine the fossils himself.

"Black died in 1933," Shapiro recalls, "and was replaced by a famous German anatomist, Franz Weidenreich. By the summer of '41 things were looking bad, so Weidenreich left China and came to New York [leaving the fossils behind]. His lab is now the staff room of the Museum. We became very close friends. I remember one day he came in to me in great despair. The fossils had disappeared."

AMNH

*The skull of Peking man, created from plaster casts of the fossils at the American Museum.*

An almost complete lack of hard information surrounded the disappearance until 1971, when Shapiro was contacted by William T. Foley, a prominent New York heart specialist. Foley had been a medical officer in the United States Marine Corps stationed in Tianjin in 1941, and he gave Shapiro some new information about the fossils. In November 1971 Shapiro wrote an article for *Natural History* in which he recounted Foley's story ("The Strange Unfinished Saga of Peking Man").

The article made front-page news across the country and reopened the search for the fossils. Six months later, Shapiro got a call from Christopher Janus, a travel agent who had just returned from China. The director of a

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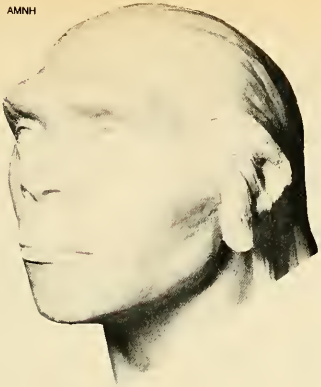

*A reconstruction by Franz Weidenreich of what Peking man probably looked like.*

new museum at Zhou Guodian (where *Sinanthropus* had been found) had gotten hold of the *Natural History* article and was tremendously excited. He urged Janus to do all he could to recover the fossils for China.

Janus returned to the States and immediately posted a $5,000 reward for information leading to the recovery of Peking man. Shapiro and Janus worked together following up many leads—mostly spurious.

"A strange story with an offer of reward is bound to attract, shall we say, imaginative people," admits Shapiro. "There was a story about the bones in a cabin high in the California hills, and so on. We even had one countess living in New Jersey who claimed she had the fossils. It's been one damn thing after another."

In 1974, Shapiro wrote *Peking Man*, a book about the fossils and their disappearance. The book concludes: "This is a tragic end that I am not yet prepared to accept until every clue has been explored and pursued."

Just recently, a new—and perhaps vital—clue has surfaced. If the information is correct, Shapiro explains, then he knows where the fossils are buried in China. "I'm reluctant to discuss it now because I'm still negotiating with the Chinese about it. It may very well turn out to be nothing, like so many other leads. I'm simply asking 'let's look into it.' Of course, I will investigate this only with the complete knowledge and cooperation of the Chinese. After all, the fossils are theirs."

*Douglas J. Preston*

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by Raymond Sokolov

# Moses and Manhasset

*Why would modern Jews maintain a kosher home in America?*

When Solomon Carvalho explored the Rocky Mountains in 1853 as the daguerrotypist on John Charles Frémont's last expedition, this Jewish adventurer did not obey the dietary laws of his religion. He ate horsemeat and mule. Similarly, Sigmund Schlesinger found no ritually pure butcher shop after he survived the Battle of Beecher Island, Colorado, in 1868, when he and fifty other scouts held off 700 Cheyenne and Sioux Indians for nine days. "Killt a Coyote & eat him all up," he wrote in his diary.

Many other Jewish immigrants ate nonkosher food in America with far less justification than Carvalho or Schlesinger. Indeed, for some refugees from Eastern European *shtetlach*, one of the attractions of America was the chance it offered to throw off the constraints of kashrus, the elaborate system of biblically based food customs and prohibitions that had been mandatory in the pious homes of their parents. My paternal grandfather emigrated to Utah in search of a secular utopia on homestead land in an agrarian commune.

Thousands of other immigrants did continue to maintain kosher homes in America. But even the Lower East Side of Manhattan, in its Jewish heyday before World War I, did not provide the same isolation as Russia's Pale of Settlement, where orthodox Jewish practice had flourished undisturbed except by czarist pogroms and oppression. One of my mother's grandfathers, a rabbi with the highest standards of talmudic observance, refused to follow his congregation to New York, convinced that the holy life was impossible there. Because of Hitler, we will never know whether he and millions of other exterminated traditional European Jews would have continued eschewing pork, separating meat and milk in the same meal, and otherwise eating orthodox Judaism's idea of pure food had they made it to the United States.

Statistically speaking, my great-grandfather's fear has been borne out by history. Given ample opportunities to assimilate into the American diet, millions of American Jews have done so. Even among those affiliated with Jewish congregations, the majority (1.1 million families) are Reform Jews who are not required to keep kosher homes. Orthodox and Conservative congregations, which officially demand the observance of kashrus, claim at least 775,000 families. These figures leave out Jews with no formal synagogue membership, most of whom presumably do not adhere to dietary tradition. Obviously, then, kosher keeping has declined. But surely more remarkable in this era of conspicuous consumption and intermarriage is that more than three-quarters of a million American households still profess allegiance to the spiritual and practical ideal of maintaining a kosher home. Indeed, some American Jews raised without any kosher principles are now converting their lives and homes to kosher practice.

Zelda and Irving Leibowitz, who live in the New York suburb of Manhasset Hills, raised their five children in a nonkosher home. Although they belong to a Conservative synagogue, their only nod to kashrus until recently had been to avoid bringing *trayf* (nonkosher foods such as pork and shellfish) into the house. Then they went with a group from their synagogue to a weekend retreat in Morristown, New Jersey, a sort of conference sponsored by the Lubavitcher hasidim, a sect of Orthodox Jews very active in wooing less observant Jews back to strict forms of piety.

"I was very impressed," says Zelda Leibowitz. "I wanted something more than Conservative Judaism."

At the retreat she learned that the Lubavitcher Women's Organization was ready to help her kosher her home. Late last year, Mrs. Leibowitz, with the support of her husband, embarked on a strenuous process that turned her kitchen upside down and completely changed her life and that of her family.

Lubavitcher representatives went through every cabinet and closet, eliminating all foodstuffs not stamped with a seal of rabbinical approval. They scrubbed her countertops and rinsed her pots with boiling water. Men took the metal pots and pans outside behind the house and burned them with a blowtorch to remove any lingering traces of food. They also took the pots in cartons to a ritual bath in Brooklyn for consecration. Unfortunately, utensils made of earthenware, glazed china, Pyrex, or Corning Ware cannot be koshered, and Mrs. Leibowitz had to give them all away. When I visited her, she was using paper plates and intending to replace her china with two new sets: one for meat dishes, the other for dairy foods.

Like all kosher principles, the separation of meat and milk is the result of divine ordinance enunciated in scripture and interpreted by rabbis over the centuries. The basic idea sounds simple, but it has ramified into a system of daunting practical complexity. To keep meat and dairy products from

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contaminating each other, Mrs. Leibowitz divided her kitchen down the middle—with one side reserved for meat, the other for dairy—and installed a second sink for her dairy dishes. Meat utensils are tagged with red tape, dairy with blue. She has kosher kitchen soaps, also in red and blue. She is not using her dishwasher pending expert advice on whether it can be salvaged. Many Orthodox Jews have two dishwashers to eliminate any doubt about milk-meat contamination through a common machine.

The principle of meat-milk separation also introduces complications into cooking and eating. A serious kosher keeper does not want his body contaminated by internal mixing of meat and milk in the digestive tract, so he eats no dairy products for six hours after eating meat. After a dairy meal, on the other hand, the wait before eating meat can be much shorter, unless one has eaten a hard, aged cheese.

Then there is the basic question of which raw materials and basic food products are kosher and which are not. Kosher meat comes only from animals that have cloven hoofs, that chew their cud, and that have been properly slaughtered. Ritual slaughter—slitting the throat swiftly with a knife—must be performed by specially trained people under strict rabbinic supervision, and about half of each animal cannot be used. Hindquarters are not kosher, because the forbidden sciatic nerve is too deeply embedded in the muscle tissue to be removed except with great difficulty. Ergo, sirloin steaks are *trayf*. So is forequarter meat from an animal with internal defects such as adhesions on its lungs. And even bona fide kosher meat has to be rinsed and salted (see recipe) or broiled, sometimes both, to extract the blood, a forbidden substance.

These requirements are only the most basic of the koshering rules for meat. The average person in modern society is simply not in a position to comply with all the provisions. As a result, it is commonplace to rely on kosher butchers. Mrs. Leibowitz goes to one near the Lubavitcher headquarters in Crown Heights, Brooklyn.

When it comes to seafood, she faces an entirely different set of perplexities. To be kosher, seafood must possess both fins and scales. (Clearly, this means that lobster and shrimp and clams are taboo.) But a kosher fish scale is special: it must be easily removable and has to form a separate integument on top of the fish's skin. Mrs. Leibowitz must therefore be able to distinguish between species of fish with kosher scales, and others (eels, swordfish, sturgeon, and catfish) with no scales or scales that are embedded in the flesh. For guidance, she can turn to a handlist of fish prepared for the Union of Orthodox Jewish Congregations of America by James W. Atz, curator and Dean bibliographer in the Department of Ichthyology of the American Museum of Natural History.

Mrs. Leibowitz and other strict kosher keepers also have to be particularly concerned about packaged foods and food additives. In effect, they depend on the judgment of professional kashrus supervisors who work for food manufacturers. These experts have to judge the kosherness of chemicals undreamed of by the authors of the Talmud, and they are not without their critics.

"Kashrus supervision has become 'big business' with big business practices," wrote Rabbi M.D. Tendler, faculty advisor to a student group at New York's Yeshiva University, which has published a brief *Guide to Kashrus*. Rabbi Tendler, in his introduction to the pamphlet, sounds like a Hebraic Ralph Nader campaigning for truth-in-labeling: "The secret process, the half-truth or actual misleading information, and the privileged information clauses written into kashrus-supervising contracts forbidding manufacturers from even answering questions related to the kashrus of their products, are . . . alien to our Torah community and rejected even by our secular society which now emphasizes the 'right of the consumer to know.'"

For her part, Zelda Leibowitz looks for the seals of rabbinic approval on packaged foods without puzzling over what Rabbi Tendler calls "the interface of food technology and kashrus laws." But even this much scrutiny adds to the special labor of her kosher shopping in modern America.

Why go through all this? What reason did the Lubavitcher hasidim give Mrs. Leibowitz that could possibly justify the daily contortions of kashrus? "No rational explanation is given in the Torah," says the author of the Lubavitcher Women's Organization's cookbook. The rules of kashrus produce health only as a "fringe benefit," but the text continues, "we observe them because they are the will of G-d and were given to us for all time at Mt. Sinai."

As a practical matter, however, the elaborate ritual of kashrus sets Jews apart from non-Jews, makes it virtually impossible for them to eat comfortably with Gentiles. By the very arduousness of its requirements, kashrus encourages the preservation of a separate Jewish identity in a non-Jewish world. To worry if a cheese was coagulated with kosher rennet is to affirm one's Jewish identity in a small but profoundly unambiguous way.

### Chopped Liver

(Adapted from *The Spice and Spirit of Kosher-Jewish Cooking*, published by the Lubavitcher Women's Organization, 770 Eastern Parkway, Brooklyn, N.Y. 11213)

1 pound beef liver
Coarse kosher salt
3 eggs, hard-boiled
1 large onion, peeled and chopped
2 tablespoons oil
½ teaspoon salt
¼ teaspoon pepper
1 tablespoon lemon juice (optional)
½ tablespoon mustard (optional)

1. Since liver has too much blood in it for salt alone to do an effective job of koshering, it is not salted in the regular way. It is salted on all sides (with coarse kosher salt) and also must be roasted over an open fire or over the open flame of a gas range (not an electric fire). If roasting a whole beef liver, cut into it across its length and width before roasting. Thoroughly wash off all outside blood and remove all visible blood clots. Salt the liver immediately before the roasting. Roast over an open fire with nothing between the fire and liver so that the blood can flow out freely. A thin wire net with large holes may be used to hold the liver over the fire. Rotate the liver a few times, so that all sides will be exposed to the fire and become roasted. If you use an open fire from a gas range, cover all sides around the open fire so that no blood can splash on the stove and render it unkosher.
2. Grind liver, eggs, and onion. (For added flavor you can sauté onion in oil first.)
3. Mix together well.
4. Add oil and seasoning and mix again.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

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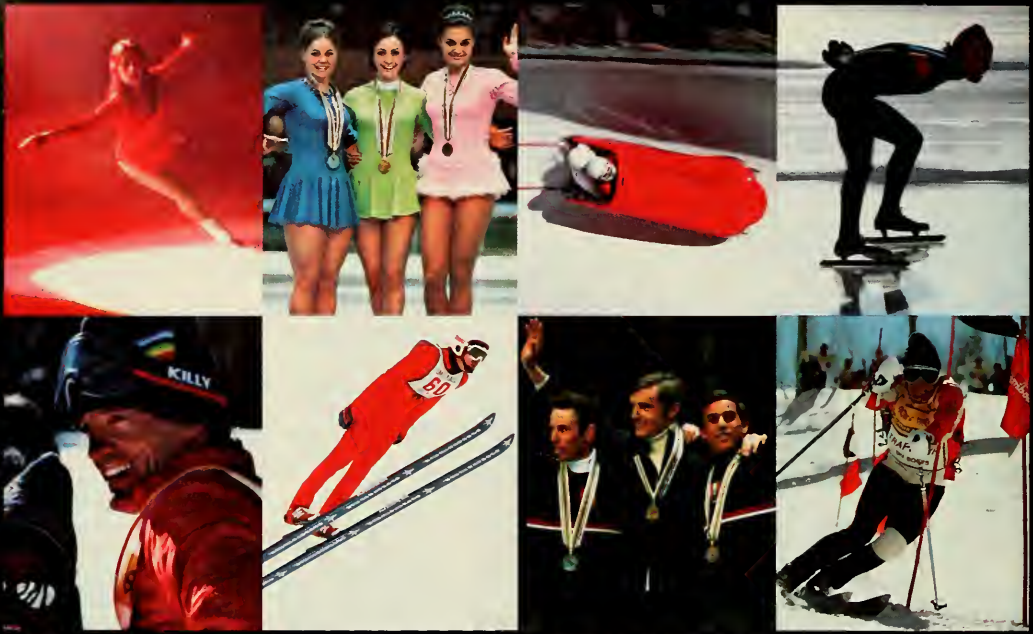

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# NATURAL HISTORY

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*Vol. 89, No. 3 (ISSN 0028-0712)*
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*Robert G. Goelet, President*
*Thomas D. Nicholson, Director*

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# Authors

**Michael Aris** encountered Bhutan's tradition of sacred dance during his five years' residence in the country, where he occupied the posts of tutor to the royal family and head of the translation department. He has made field trips with his Burmese wife and two sons to Sikkim, Nepal, and northern India. Currently research fellow in oriental studies at St. John's College, Oxford, Aris's major interest is Tibetan and Himalayan history and culture. In 1979 he convened in Oxford the International Seminar on Tibetan Studies. His forthcoming book, *Bhutan: The Early History of a Himalayan Kingdom*, is based on his Ph.D. dissertation for the University of London.

Curator of the department of herpetology of the Atlanta Zoological Society, **R. Howard Hunt** has done much of his research on the ecology and ethology of spiders. In addition to his work on the relationship between tarantulas and narrow-mouthed toads, he is studying the trapdoor spider and the black widow. He writes that he "occasionally finds the sight and sound of humans repugnant and seeks relief spelunking and rappelling in the mountains of north Georgia." Hunt also fancies himself a writer of horror short stories.

In order to observe a mule deer buck's behavior, **Valerius Geist** has tagged along for hours as the animal ambled through the woods. His knowledge of deer and their habitat has made such fieldwork almost routine. Born in the USSR, Geist, now professor and associate dean of the Faculty of Environmental Design at the University of Calgary in Canada, has made a specialty of ungulate ecology. Commenting on his avocations and diversions, he says that his "hobbies, daydreaming, research, and teachings are not easily separated." He enjoys gardening, cooking, wine, and "arguing until there is no one left to discuss a subject with."

**Mary A. McWhinnie** started working in Antarctica in 1963 aboard the research vessel *Eltanin*. After several cruises, she began investigating the metabolic adaptations of antarctic crustaceans in order to discover how they carry on their life functions in such a frigid environment. During that study, McWhinnie spent an entire year at McMurdo Station, becoming the first woman scientist to winter over in Antarctica. In 1975, she shifted her base of operations from McMurdo to Palmer Station, where she initiated intensive research on the biology of krill. She designed large flow-through seawater aquariums, now at Palmer, which have made possible the long-term captive maintenance of krill with consequent breakthroughs in the understanding of the crustacean's biology. Altogether, McWhinnie has been to Antarctica ten times. When not on that ice-bound continent, she is a professor of biological sciences at DePaul University in Chicago.

After working for several years in dult education, coauthor **Charlene J. Denys** returned to her first love, biolgy, and is currently in the doctoral rogram of the Biology Department at DePaul. She has been working with McWhinnie, her adviser, for the past ve years and has made four research ips to Antarctica. During her first seaon there in 1975, she became intersted in the swarming behavior of krill nd the possible role of vision and bioiminescence in keeping the animals in eir characteristic aggregations. "The eer beauty of their luminescent dislays," she says, undoubtedly contribted to that interest. Denys will spend he upcoming antarctic austral season tudying krill vision. She adds that 'considering what it takes to get to and rom Antarctica, I am lucky that travelng is my favorite avocation."

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# The Slow Comeback of Gardiner's Ospreys

Dennis Puleston

Gardiner's Island in the 1930s and 1940s had perhaps the greatest concentration of nesting ospreys in the world—an estimated 300 nests producing about two young each. When spraying of DDT began on neighboring Long Island in the late 1940s, the osprey population plummeted. By 1965 there were less than sixty nests on the island and only four young were fledged. Thin-shelled eggs, a characteristic sign of DDT ingestion by birds, showed concentrations of more than 13 parts per million of the insecticide.

The spraying was finally stopped in the mid-1960s. And, as Dennis Puleston wrote in "Return of the Osprey" (February 1975), the birds began to make a slow recovery. By 1974, a total of twenty-six young were fledged from thirty-four active nests, and one unhatched egg showed only 3.59 ppm of DDT.

Since then, Puleston reports, the recovery has continued, with a minor setback in 1979 because of cold weather and rain when the young were hatching. In the two previous years the reproductive rate crept over one bird per nest for the first time since the mid-1950s. In both years there were thirty nests. Thirty-one young were fledged in 1977 and thirty-four in 1978. (Last year twenty-six young were fledged from twenty-six nests.) Another encouraging sign is that an unhatched egg in 1978 showed less than one ppm of DDT.

## The Difficulty of Staying Frozen

Having one's body kept intact at 320 degrees below zero might seem cold comfort to most of us. But for some people suspension (after death) in a large thermos filled with liquid nitrogen offers the hope of being brought back to life, or cloned into a surrogate second life, at some future time when the powers of science have grown.

In December 1971 *Natural History* reported on the case for and against cryonic suspension ("Immortality and the Freezing of Human Bodies"). At that time thirteen people had been frozen and were staying frozen in the United States. Their numbers have not increased.

Last fall, Art Quaife, who runs the only commercial cryonic suspension operation in the country, Trans Time, Inc., in Berkeley, California, had seven "patients" in cold storage. Curtis Henderson, who describes himself as the sole surviving member of the Cryonics Society of New York (the others didn't die, they moved to California), said he believed there was probably only one other body in the country that was being kept in liquid nitrogen.

What happened to the others? Apparently, they've been thawed, al-

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# The 80th-Anniversary Natural History Photographic Competition Closes April 1

To celebrate its eightieth year of publication, and to entice you to submit your best photographs, *Natural History* has put together a bountiful package of awards for the winners of this year's photographic competition.

The Grand Prize-winner of the 80th-Anniversary *Natural History* Photographic Competition will be invited to join the American Museum of Natural History's two-week cruise around Britain and Ireland in July. This $3,000-plus prize includes air fare from New York and accommodations on the luxury cruise ship *Orpheus*.

The itinerary includes London, Southampton, Dover, Edinburgh, the Shetland Islands, Loch Ewe, Galway, Holyhead, and Guernsey, with land excursions to Canterbury, Hadrian's Wall, Holy Cross, and spectacular natural settings.

Thomas D. Nicholson, director of the American Museum and astronomer, and six other scholars will introduce travelers to the archeological, historical, and natural treasures along the route.

The 80th-anniversary competition also will award seventeen cash prizes totaling $3,500. The winning entries will be published in the July issue of *Natural History* and exhibited at the American Museum of Natural History.

First prizes of $500 each will be awarded in three major categories: The Human Family; Animals (including birds and bugs); and Plants and Their Environment. Merit Awards of $250 each will go to the best entries in four categories: Photomicrography; A Sequence in Nature (up to five photographs); Urban Wildlife; and Humor in Nature. Ten Honorable Mentions of $100 each will be selected from all entries.

Competitors may submit up to five entries in the competition.

The deadline is April 1, 1980. Please put your name and address on every entry and include a stamped, self-addressed envelope—since we want to return your pictures to you.

And good luck!

## THE RULES

1. The competition is open to everyone except employees of the American Museum and their kin.
2. Competitors may submit up to five previously unpublished entries (a sequence is considered a single entry).
3. The Museum acquires the right to publish, exhibit, and use for promotion the winning photographs. The Museum assumes no responsibility for other entries.
4. Entries may be transparencies or prints, either color or black and white, up to 8 by 10 inches. Each must bear the photographer's name and address.
5. Enclose a self-addressed, stamped envelope for the return of entries.
6. Entries must be postmarked no later than April 1, 1980.

Pack them carefully and mail them to:

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though Henderson and Quaife said they knew of no central source of information on who is frozen where. Henderson did point out that unless you can set up a trust for perpetual maintenance in a frozen condition, you have to rely on the good will of your descendants, a risky proposition considering the cost of cryonic suspension. In 1971 it cost as much as $8,500 to be frozen and $1,000 a year to stay frozen. Inflation has, of course, changed those figures. At Trans Time, the cost is now $12,000 to start and $2,000 a year after that. If posterity gets cold feet, an untimely thaw may be in the offing.

## A Historic Place, Underwater

In January of 1781 the British warship *Culloden*, carrying seventy-four guns, ran aground off Long Island's Montauk Point (not far from Gardiner's Island). The British spent three weeks stripping the ship and then burned her to the waterline to prevent the colonists from salvaging anything from her. Nonetheless, unruly Americans managed to get some of the ship's iron and copper before she disappeared from view.

In 1971 Henry W. Moeller (coauthor with Steven A. Giordano of "The Search for the *Culloden*," December 1976) found the ship's remains and conducted an underwater archeological dig on the site. Last year Moeller's efforts were rewarded in a small way when the ship was named to the National Register of Historic Places. Being on the register affords some protection to the site, since it marks it as a cultural resource that must be taken into account if a government project affects it.

Unfortunately, it affords no protection against the colonists, who are still snatching what they can from the more than 500 wrecks that went down off Montauk in the last 200 years. The difference is that now they have scuba gear. The *Culloden* site has little left to take, but Moeller suffered problems from pilferage while he was waiting for official approval to conduct the dig. And many other wrecks with artifacts of historic value are regularly picked over by divers, according to Moeller, who sees little hope for a change in the situation. There are laws on the books to protect the wrecks, but no real provision for enforcement.

*James Gorman*

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# So Firm a Friendship

*Some guarding dogs follow, and defend, a flock of sheep as if they were part of it*

**by Lorna Coppinger and Raymond Coppinger**

In the *Voyage of the Beagle*, Charles Darwin wrote, "When riding, it is a common thing to meet a large flock of sheep guarded by one or two dogs, at the distance of some miles from any house or man. I often wondered how so firm a friendship had been established."

In the spring of 1977, we began our own attempt to investigate the basis of this friendship, traveling from Hampshire College in the hills of western Massachusetts to the sheep pastures of Europe, in search of a "new" biological solution to an old biological problem: predation on sheep by wolves, dogs, and other canids. High in the newly green mountains of Macedonia in southwestern Yugoslavia, we established contact with several shaggy descendants of this region's legendary sheep-guarding dogs. For days we had watched thousands upon thousands of long-tailed, white-faced woolly sheep being moved by shepherds from the lowlands, through large culverts under highways, up the eroded trails of the foothills to their summer range in the Šar Planina. Plodding along shoulder to shoulder with the sheep, shepherds, and pack ponies were the dogs: two or three sheep-sized dogs for every half mile of sheep.

To test for ourselves the dogs' reputation we approached a flock of several hundred sheep, watching the placid dogs out of the corners of our eyes. Our approach roused a dog from his afternoon reverie, and he moved slowly so that our path to the sheep now included him. He seemed unconcerned and relaxed, but when we got to about fifty yards from the nearest sheep, we decided that we had reached our safe limit. The dog still showed no overt threat, but a slight change in his stance and the lowering of his head and tail as he watched us convinced us of his guarding abilities.

In later months we would watch similar behavior in dozens of Old World sheep-guarding dogs: Italian maremma, Yugoslavian šar planinetz, Turkish (Anatolian) shepherd, Hungarian komondor and kuvasz, and also two Russian-type ovcharkas (sheepdogs) that our colleague Susan Goldhor brought to Hampshire College from the mountains of Turkey near the Russian border. In all the dogs, we noted what Charles Darwin wrote in 1833 about the sheep-guarding dog in South America: "It has no wish to leave the flock, and just as another dog will defend its master, man, so will these the sheep. It is amusing to observe, when approaching a flock, how the dog immediately advances barking, and the sheep all close in his rear, as if round the oldest ram."

The year before, we had been discussing traditional European guarding dogs with Richard Wheeler and Hudson Glimp at the Winrock International Livestock Research and Training Center in Arkansas. As leaders in the sheep industry, they were well aware in 1976

*From Portugal to Tibet, sheep-guarding dogs, such as these Hungarian komondor, are the pride of shepherds. U.S. sheepmen, plagued by coyotes and marauding dogs, are now looking to this Old World means of predator control.*

János Eifert

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For three decades the engineers at Sony have een behind not just one or two, but eighteen major chnological innovations in high fidelity. One of our ngineers even won a Nobel Prize.

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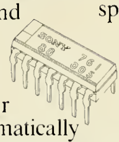

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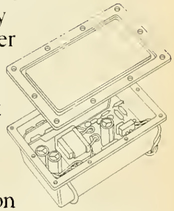

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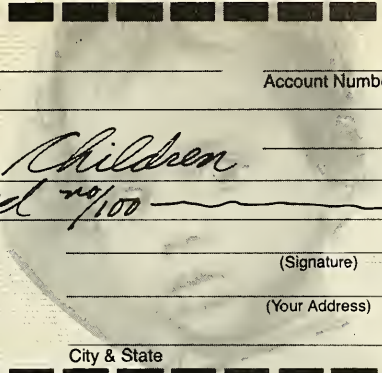
of the need of United States sheep producers for more help in protecting their flocks from predators. Since 1972, when the poison known as compound 1080 was banned on public grazing lands, the coyote problem had increased steadily across the western United States, and so had the cost of predator control. Despite the $30 million spent in one year on control of canids, well over a million sheep were reported lost, mostly to coyotes.

Government statistics on losses to coyotes in the major western sheep-producing states vary from 8 percent of all lambs born to 2 percent of the annual sheep inventory. Percentages do not, of course, reflect individual experience. Sheep farmers on the periphery of a sheep-raising area frequently serve as a buffer for those in a more protected situation, and since their ranges are more exposed to predators, they may suffer heavier losses.

And, of course, what a loss means to a shepherd is another thing. One Massachusetts shepherd lost twenty-five of his forty-four ewes in one night, killed by dogs in his barn. His lambs, in another section, survived, but then he had to absorb the cost of bottle feeding thirty-four two- to five-week-old lambs. A Boston businessman who raises cattle on thousands of acres in Arizona told us that no loss is "acceptable," and that an 8 percent yearly toll would put him out of the livestock business.

Modern research has produced sophisticated methods of predator control, including such lethal and nonlethal devices as toxic sheep collars, cyanide guns, repellent odors, traps with tranquilizers, chemosterilants, and supercharged electric fences imported from New Zealand. Applying these systems is fraught with frustrations: scientists at Colorado State University concluded that no chemical odor they had found would consistently repel canids without also adversely affecting sheep; researchers at the Denver Wildlife Center noted that commercially available tranquilizers were prohibitively expensive for large-scale use; at Texas A & M University, investigators found that the resourceful coyote, while preferring to go under or through fences, rose to the challenge of five-foot barriers and promptly learned to jump them.

Besides these technical snags, there is a controversy over what predator control methods are acceptable. A November 1979 directive from Secretary



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☐ Boy ☐ Girl ☐ Either

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- ☐ Israel
- ☐ Korea
- ☐ Lebanon
- ☐ Mediterranean
- ☐ Mexico
- ☐ Southern States (U.S.)
- ☐ Sri Lanka (Ceylon)

**3 Would you like a picture of your sponsored child?**
Shortly after we select a child for you, we can send you a photograph and brief personal history, if you desire.
☐ Yes ☐ No

**4 Would you like to correspond with your sponsored child?**
If desired, correspondence can help build a meaningful one-to-one relationship. Translations, where necessary, are supplied by Save the Children.
☐ Yes ☐ No

**5 Would you like information about the child's community?**
Several times a year you can receive detailed reports on community activities to benefit your sponsored child. These community reports show how your money is being used most effectively for permanent improvements to the child's environment—for health care, education, food production, nutrition, and community training. Would you like to receive such information?
☐ Yes ☐ No

**6 Do you wish verification of Save the Children credentials?**
Save the Children is indeed proud of the handling of its funds. Based on last year's audit, an exceptionally large percentage (80.3%) of each dollar spent was used for program services and direct aid to children and their communities. Due to volunteered labor and materials, your donation provides your sponsored child with benefits worth many times your total gift. Would you like to receive an informative Annual Report (including a summary financial statement)?
☐ Yes ☐ No
*(A complete audit statement is available upon request.)*

**7 Would you rather make a contribution than become a sponsor at this time?**
☐ Yes, enclosed is my contribution of $______.
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of the Interior Cecil D. Andrus stated that official policy for federal grazing lands would now emphasize nonlethal, noncapture methods of control, that only the animals actually doing the damage would be removed, and then only by humane methods. Thus the conflict between the global need for food and fiber and the ethical question of attacking a wild species is intensifying. On hearing the news from Secretary Andrus, large-scale producers began thinking seriously about livestock-guarding dogs.

Only two breeds of traditional European guarding dogs were known to a handful of U.S. farmers by the mid-1970s. Although both the French/Spanish great pyrenees and the Hungarian komondor and kuvasz had been available commercially for several decades, the kuvasz was not used with livestock, and the success of the others as sheep guardians in the United States was highly variable. Some dogs reduced predation while others added to it. Farmers were naturally reluctant to trust their sheep to unsupervised dogs.

In Europe and Asia, however, using dogs to control predators has a long history. For shepherds to have so many big dogs, they all must earn their keep. The Spanish shepherds who brought sheep to the New World thought enough of their guarding dogs to bring them, too. Today, from Portugal to Tibet, the various guarding breeds are the prides of the shepherds and are kept by many. Although wolf and lynx populations are greatly reduced in most of Europe and southwestern Asia, they, along with human thieves, still pose a problem to shepherds. In fact, the night before we confronted our first šar planinetz in the mountains of Yugoslavia, a wolf had bothered the flock.

At Hampshire College, our initial two years of research included importing ten pups of three different breeds from European working stock, breeding and raising the first U.S. generations, noting behavior, and then placing seventy young dogs out on farms and ranches across the country. Our experience has mirrored much of what Darwin recorded.

Darwin was one of many observers who assumed that the guarding behaviors must reflect careful training:

> The method of education consists in separating the puppy, while very young, from the bitch, and in accustoming it to its future companions. An ewe is held three or four times a day for the little thing to suck, and a nest of wool is made for it in the sheep-pen; at no time is it allowed to associate with other dogs, or with the children of the family.

We found out, however, that the behavior of the guarding dogs is primarily unlearned. There is little one needs to do with these dogs to foster three characteristic, and necessary, behaviors: nonaggression toward the sheep, attentiveness to the sheep ("following instinct"), and defense of the sheep. These behaviors contrast dramatically with those of herding dogs such as border collies, which have been bred to capitalize on their basic instinct to stalk and chase. With herding dogs, the shepherd regulates the rate and direction of the chase and inhibits its predatory outcome. Depending on how intense this instinct is, farmers can select more timid breeds or strains for work with smaller livestock, such as sheep, and more aggressive dogs for cattle.

If puppies of both guarding and herding breeds are raised together, one finds little difference in their behavior until puberty (about seven months old). Play behavior and social development occur at similar rates, with the guarding dogs tending to be more dominant, apparently for reasons of size. Of course, a small guarding dog bitch may be dominated at the food pan by a larger male herding dog.

Nearing puberty, the border collie herding dogs we worked with suddenly developed a new behavior called "eye," in which the dog stares fixedly at an object. It is basically a stalking behavior. The frequency of this behavior was extraordinary, sometimes absorbing the dogs during most of their active periods. Eye became a permanent part of the dogs' play repertoires and at times groups of border collies would eye each other or some other object (such as an apprehensive chicken) for hours. One female would kick up dust, leap around, and eye its descent, over and over. Motion or the anticipation of motion seemed to be an important stimulus for eliciting this eye behavior. Closely related, and also age-dependent, are the behaviors of other working breeds of dogs, such as pointing in pointers and setters or retrieving in retrievers.

The guarding dogs, on the other hand, show no new motor patterns at puberty. Instead, the dogs' juvenile behavior is retained and its strength intensifies. They play and fight harder and,

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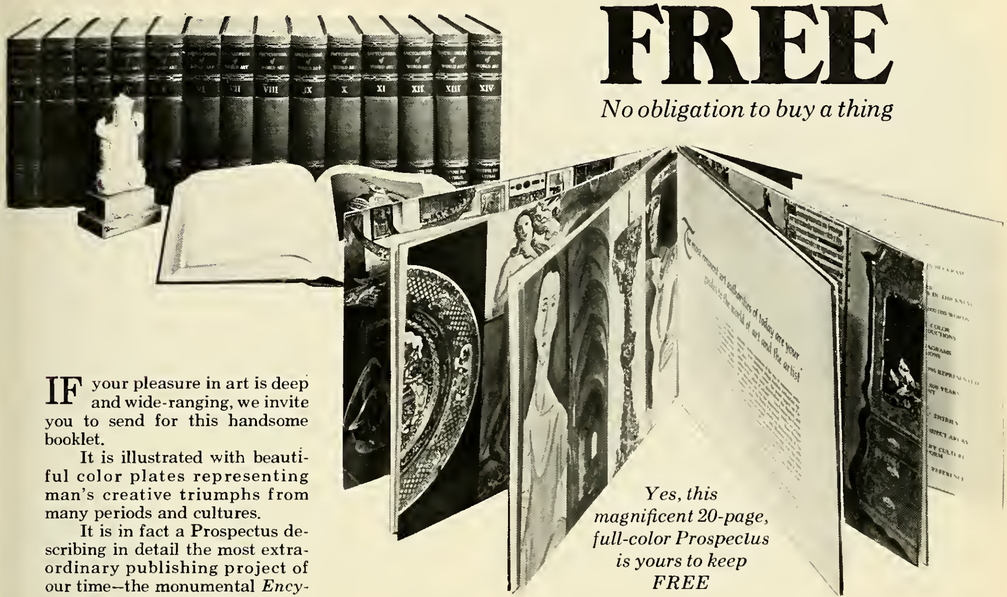

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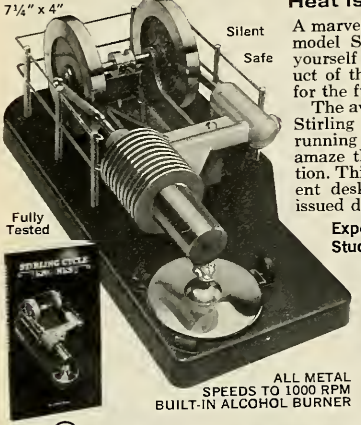

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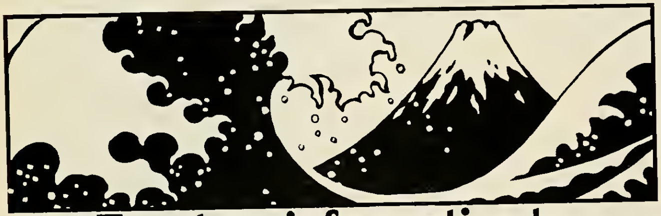

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as Darwin noted, this can be a real problem for sheep: "Their most troublesome fault, when young, is their desire of playing with the sheep; for in their sport they sometimes gallop their poor subjects most unmercifully." Often an aggressive ram or ewe curbs this overplayful behavior with a foot-stamp or butt, or the shepherd intercedes by punishing or restraining the dog for a while.

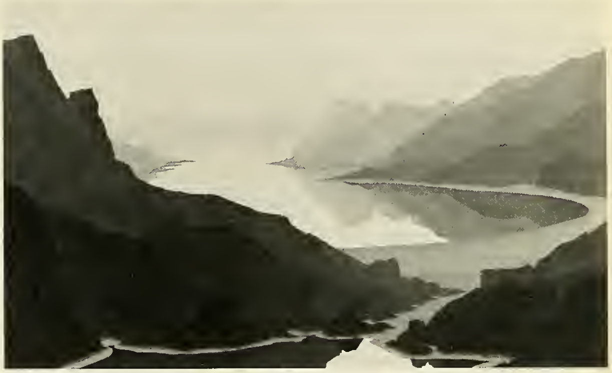
Once past this juvenile stage, however, the dogs and sheep form a social bond. An adolescent dog's sexual behavior often becomes part of the play. A dog will solicit play from a sheep with a play bow, followed by a chase if the sheep will run. The sheep is at a disadvantage in this play, often losing wool or worse. If the sheep stands, the dog may mount the animal and include pelvic thrusts, often protracted if the sheep seems receptive. Another sexual pattern exhibited by the dog is to nuzzle the sheep's ear, sometimes hanging on to it if the sheep tries to move away. The result can be a torn ear.

If the sheep demonstrates aggression toward the dog's play bow by lowering its head and walking slowly and steadily toward the dog, the dog may retreat, showing characteristic submissive behavior by lowering its haunches and turning a back knee out. Frequently, a guarding dog will start licking a sheep's face in a routine reminiscent of a food-begging performance used by pups to get their mother to regurgitate food. Sheep will often tolerate this licking for long periods.

After the dog matures, the rambunctious play decreases in intensity, although many of these behaviors remain long into its adult life. Two-year-old dogs, more stately in motion, will walk up to a flock, lick a face, nuzzle an ear, act submissive, or mount a sheep. Experienced sheep pay little attention or participate moderately.

The behaviors that spell success for a guardian are absence of the stalking, chasing instinct and a curious mixture of juvenile, maternal, and courtship behavior directed toward the sheep. We often hear a shepherd say that the dog thinks he is a sheep. More likely the dog is treating the sheep as if they were other dogs. Dogs dominate sheep, drive them from food with a characteristic vocal warning, nuzzle their ears, and lick their genitals; even try to copulate with them. Some dogs and bitches will lick newborn lambs clean and cuddle them in the crotch of

# How to tell original prints from cheap reproductions.


Jerome Schurr's *Padres Bay*, original serigraph. Signed limited edition of 290.

Buying original prints is an excellent way for the novice to make a modest investment in beautiful works of art.

The buyer had better beware, however.

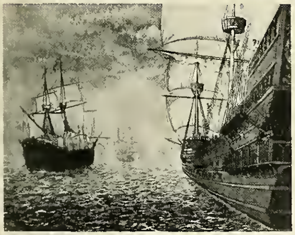
As more and more attention is being given to art as an investment, more and more dealers are trying to pass off cheap reproductions as fine art.

At the Original Print Collectors Group, we sell only fine original works to a growing number of people who are enthusiastic about buying good art at moderate prices.

One of our primary concerns is to educate our customers, so that they'll be able to discriminate and get true value for their money. A few pointers, then about original prints:

Original prints, whatever the process used to create them, are "hand-pulled" under the artist's supervision, or by the artist himself. This means that any work produced photographically or by another purely mechanical process is not an *original* print.

If you examine a print under a magnifying glass and discover a regular pattern of small dots, you will know immediately that it is not an original work.

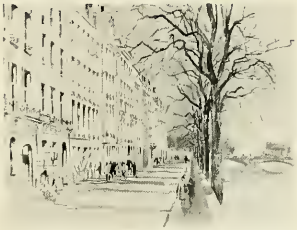

Paul Tappenden's *Voyage to the New World*, original etching. Signed limited edition of 250.

If the print is a serigraph (produced by a silkscreen process), the ink will seem rather like paint and appear to be sitting upon (rather than absorbed into) the paper.

Etchings and engravings will produce a physical impression on the paper itself.

Contemporary original prints will always be signed in pencil by the artist himself, to indicate personal supervision and approval of the individual print.

Original prints are always produced in limited editions, at the most several hundred copies. If thousands of copies are available, then the work is almost certainly *not* original. (In most cases, to assure that the integrity of their work is not violated, artists will destroy the plate after the edition has been produced.)


Pierre Pages' *Quai d'Orleons*, original lithograph. Signed limited edition of 225.

The print will have a figure on its border, indicating the number of prints pulled and the number of the individual print in the sequence.

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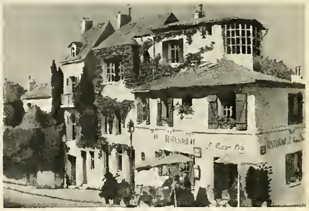
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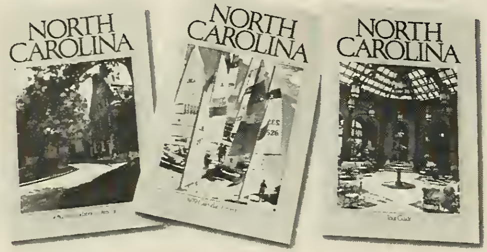

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their hind leg, curling around them as if the lamb were a puppy.

All these behaviors lessen the chances that a dog will kill a sheep and also predispose the dog to follow the sheep. The behaviors closely resemble those that one might record among members of a pack of wolves. The dog is treating the sheep like other dogs; the sheep are treating the dogs like other sheep. Both sheep and dogs, together in a flock, respond to each other's feeding behavior and alarm signals, and they sexually solicit one another.

In studying this social bonding, we have tried to manipulate its development. Cynthia Arons, a fourth-year student at Hampshire College, divided six litters of guarding and herding dog pups shortly after birth and suckled half on sheep and half with their own mothers. She was looking for confirmation of the presumed benefit derived from the traditional technique of suckling pups on ewes, as reported to us—as well as to Darwin—by numerous shepherds. The dogs, now in their second year, show no difference in social attachments to sheep. In fact, some Anatolian shepherd dogs, which were donated to the project at an age of six months and had never seen a sheep before, seemed delighted with their new friends in our sheep pasture and went right to work. We still advise farmers, however, to raise their dogs under close observation, particularly until they are at least a year old.

How then do the sheep gain protection from predators by the presence of guarding dogs? First and most important is that most predators will not risk approaching a flock where one or more 100-pound dogs are on duty. Sheep predators are mainly canids, and most of the primary social signals are common to wolves, coyotes, and dogs. Much of the time we cannot tell directly how effective the guardians are because when they are with the sheep, nothing happens. Predation is usually erratic, so the lack of it is hard to measure, especially since it may be simply the dog's presence or barking that warns the predator away. Nevertheless, we have recorded some clear instances of steady predation that stopped, literally overnight, when adult dogs were put out with the flock.

The second protective mechanism is closely related to the first. Dogs are attracted to other dogs. A potential predator may enter a field with mutton on his mind but he can be quickly diverted into sniffing rear ends and pos-

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turing with the guarding dog. If the new animal establishes dominance over the guardian then it might go on to kill sheep, but more times than not, size wins out and the shepherd finds a submissive neighborhood pet, unharmed, in the field.

Third, our guarding dogs respond negatively to any new stimuli, any small changes in the routine activities of a pasture. Barking is elicited by minor stimuli; habituation to these is slow. The guardians' apprehension is heightened in the twilight periods of the day, when coyotes and unwanted dogs are most active. Guardians react to potential encroachers with barking, usually with their tail down and ears back. This is typical "fight or flight" behavior. In young dogs the tendency is to flight, but the more mature will stand their ground, although they seldom move far from their "supporting" group of sheep. This means the dog stays with the flock, approaching an intruder and then retreating, its courage waxing and waning according to its proximity to the sheep. If there are two or more guardians present, they will form an alliance, which puts a serious predator at a disadvantage.

Preliminary reports on the first trials of our guarding dogs are encouraging. The nearly seventy farmers and ranchers who have been cooperating with the Livestock Dog Project report that during their first two years most of the dogs have shown the social attachment to sheep that is necessary for effective guarding. The rest of the dogs may need another year to develop reliability. Some may never make it.

How many sheep have been saved these first two years? We have no hard data yet, but most of those using the dogs write that since the guardian joined their sheep, very few predators have ever been seen. One farmer did lose eight sheep to two local pet dogs while his two young guardians stayed bunched with the flock. These littermates have since been separated and sent to other farms, and maturity seems to be increasing their confidence. Another farmer with three sheep pastures and two dogs lost sheep one night but only in the one unguarded pasture. A third farmer who had been losing a lamb a night lost no more once an experienced guarding dog joined his flock.

Darwin wrote,

> A whole pack of the hungry wild dogs will scarcely ever (and I was told by some never) venture to attack a flock guarded by even one of these faithful shepherds. The whole account appears to me a curious instance of the pliability of the affections in the dog; . . . We can understand on no principle the wild dogs being driven away by the single one with its flock, except that they consider . . . that the one thus associated gains power, as if in company with its own kind.

The bond formed between the two species, dogs and sheep, results in a firm friendship indeed. From both historical and biological points of view, guarding dogs hold the promise of an environmentally sound, cheap way of reducing predation on livestock.

*Lorna Coppinger, a faculty associate in biology, and her husband, Raymond Coppinger, a professor of biology at Hampshire College in Amherst, Massachusetts, run the Livestock Dog Project at Hampshire's New England Farm Center. They have been studying the behavior and physiology of dogs since the early 1960s.*

*Sheep raisers say that dogs such as these Turkish shepherds think they are sheep. More likely, the dogs treat the sheep as if they were other dogs: nuzzling their ears, licking their genitals, even trying to copulate with them.*

Ralph Gates

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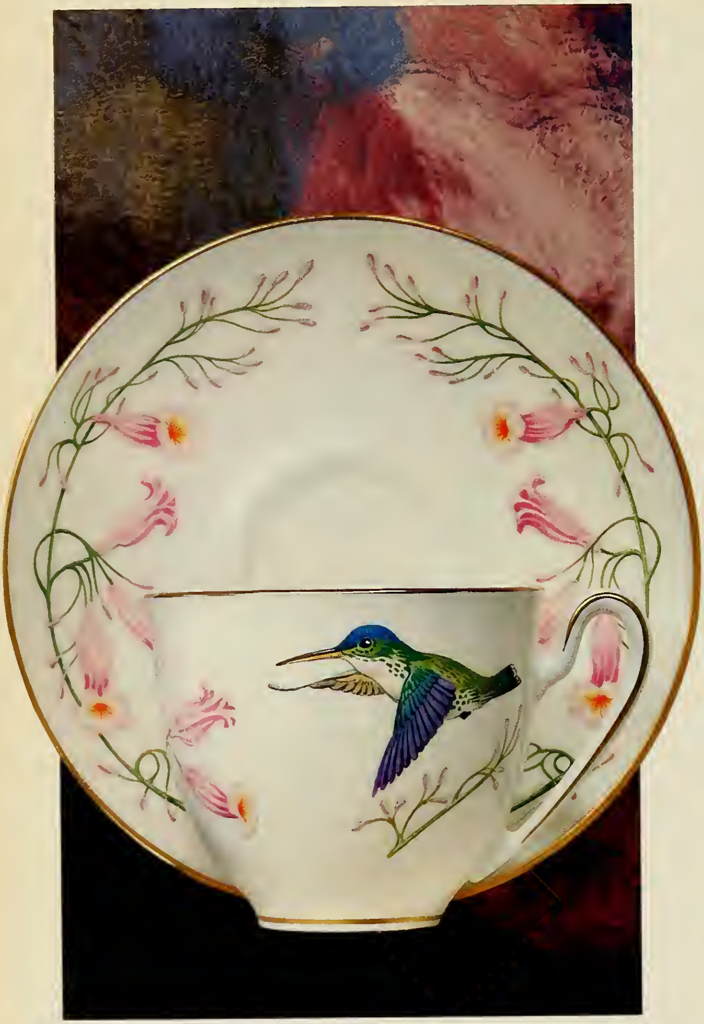

# hummingbirds of the world

by Robin Hill

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**The Hummingbird cups and saucers.** The collection is an official issue of the World Wildlife Fund, the world's largest privately supported nature conservation organization. It is the World Wildlife Fund's *first* international issue in porcelain.

The cups and saucers will be crafted in fine Bavarian porcelain, whose exceptional whiteness is ideally suited to bring out the dazzling beauty of the hummingbirds. And each hummingbird will be associated, in Hill's superb works of art, with its favored flower. The vivid leaves and bright blossoms provide a perfect setting for the hummingbirds shown on the front and back of each cup.

Here is how the great naturalist painter John James Audubon described this beautiful, tiny bird:

> "A glittering fragment of the rainbow...
> moving through the air...as if by magic...
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The cups and saucers will be crafted solely for subscribers. Individual cups and saucers will not be sold separately. And there is a further limit of one subscription per collector.

The total edition will thus be forever limited to the exact number of original subscriptions entered by March 31, 1980.

**Subscription deadline: March 31, 1980.** The collection will be issued on a convenient subscription plan, at the rate of one cup and saucer every other month. The original issue price of just $39 per cup and saucer is payable in two equal monthly installments of $19.50 each. And each cup and saucer will be accompanied by a special stand, so that you can display them in your own home just as they are shown on these pages—the saucer on its edge and the cup in front of it, forming a charming and complete composition.

In addition, each cup and saucer will be accompanied by a commentary written especially for this collection, describing the hummingbird portrayed, its native habitat, its favored flowers and much other fascinating lore. A Certificate of Authenticity, attesting to the limits of edition, will accompany each collection.

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The World Wildlife Fund has appointed Franklin Porcelain to service and fulfill all subscriptions to the Hummingbirds of the World collection.

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**This View of Life** — **by Stephen Jay Gould**

# Death before Birth

*In nature, and in Latin, the exception* probes *the rule*

Can anything be more demoralizing than parental incompetence before the most obvious and innocent of children's questions: Why is the sky blue, grass green? Why does the moon have phases? Our embarrassment is especially acute because we thought we knew the answers perfectly well, but hadn't rehearsed them since we ourselves had received a bumbled response in similar circumstances a generation earlier. It is the things we think we know—because they are so elementary or because they surround us—that often present the greatest difficulties when we are actually challenged to explain them.

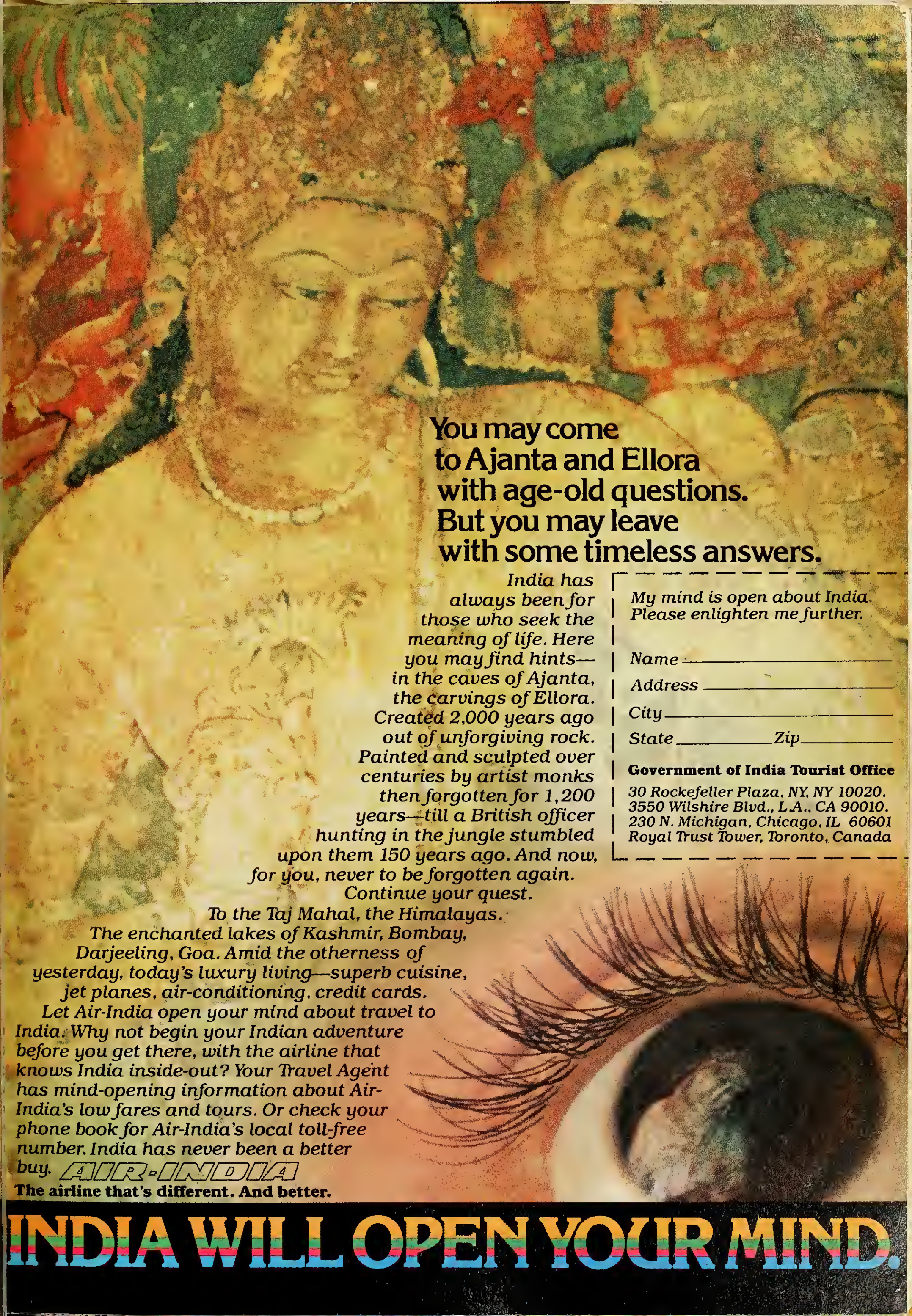
One such question, with an obvious and incorrect answer, lies close to our biological lives: Why, in humans (and in most species familiar to us), are males and females produced in approximately equal numbers? (Actually, males are more common than females at birth in humans, but differential mortality of males leads to a female majority in later life. Still, the departures from a one to one ratio are never great.) At first glance, the answer seems to be, as in Rabelais's motto, "Plain as a nose in a man's face." After all, sexual reproduction requires a mate; equal numbers imply universal mating—the happy Darwinian status of maximal reproductive capacity.

At second glance, it isn't so clear at all, and we are drawn in confusion to Shakespeare's recasting of the simile: "O jest unseen, inscrutable, invisible,/ As a nose on a man's face, . . ." If maximal reproductive capacity is the optimal state for a species, then why make equal numbers of males and females. Females, after all, set the limit upon numbers of offspring, since eggs are so much larger and so much less abundant than sperm—that is, each egg can make an offspring, each sperm cannot.

A male can impregnate several females. If a male can mate with nine females and the population contains 100 individuals, why not make 10 males and 90 females. Reproductive capacity will certainly exceed that of a population made of 50 males and 50 females. Populations made predominantly of females should, by their more rapid rates of reproduction, win any evolutionary race with populations that maintain equality in numbers between the sexes.

What appeared obvious is rendered problematical: Why do most sexual species contain approximately equal numbers of males and females? The answer, according to most evolutionary biologists, lies in a recognition that Darwin's theory of natural selection speaks only of struggle among *individuals* for reproductive success. It contains no statement about the good of the population, the species, or the ecosystem. My previous argument was framed in terms of advantages for populations as a whole—the usual, congenial, and dead wrong way in which most people think of evolution. If evolution worked for the good of populations as a whole, then sexual species would contain relatively few males.

The observed equality of males and females, in the face of obvious advantages for female predominance if evolution worked upon groups, stands as one of our most elegant demonstrations that Darwin was right—natural selection works by the struggle of individuals to maximize their own reproductive success. The Darwinian argument was first framed by the great British mathematical biologist R.A. Fisher. Suppose, Fisher argued, that either sex began to predominate. Let us say, for example, that fewer males than females are born. Males now begin to leave more offspring than females since their opportunities for mating in-



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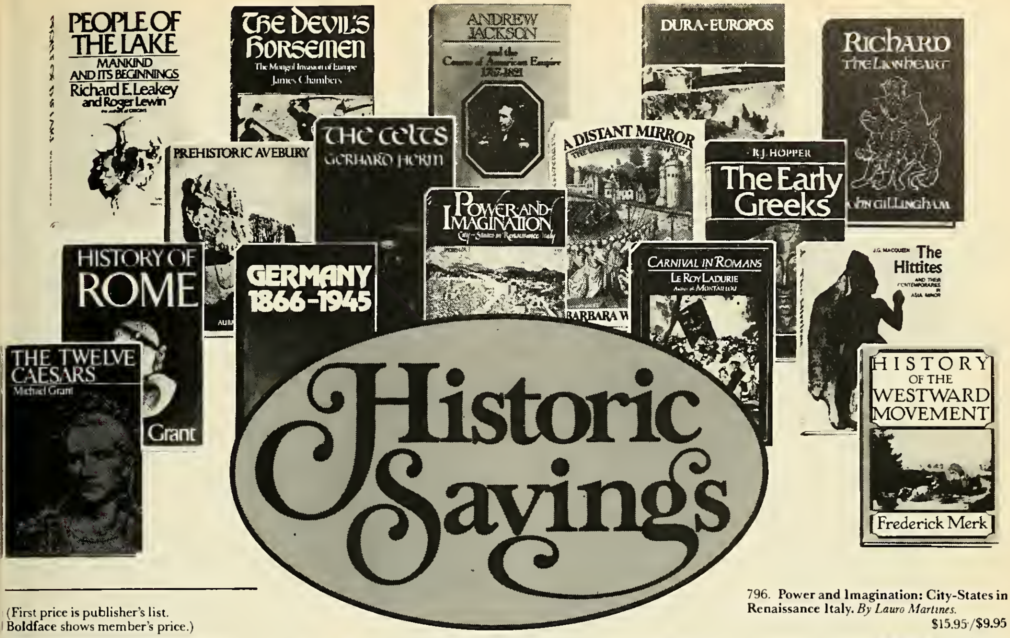
crease as they become rarer—that is, they impregnate more than one female on average. Thus, if any genetic factors influence the relative proportion of males born to a parent (and such factors do exist), then parents with a genetic inclination to produce males will gain a Darwinian advantage—they will produce more than an average number of grandchildren thanks to the superior reproductive success of their predominantly male offspring. Thus, genes that favor the production of males will spread and male births will rise in frequency. But this advantage for males fades out as male births increase and it disappears entirely when males equal females in number. Since the same argument works in reverse to favor female births when females are rare, the sex ratio is driven by Darwinian processes to its equilibrium value of one to one.

But how would a biologist go about testing Fisher's theory of sex ratio? Ironically, the species that match its predictions are no great help beyond the initial observation. Once we frame the basic argument and determine that the species we know best have equal numbers of males and females, what do we achieve by finding that the next thousand species are similarly ordered? Sure, it all fits, but we do not gain an equal amount of confidence each time we add a new species. Perhaps the one to one ratio exists for another reason?

To test Fisher's theory, we must look for exceptions. We must seek unusual situations in which the premises of Fisher's theory are *not* met—situations that lead to a specific prediction about how sex ratio should depart from one to one. If change of premises leads to a definite and successful prediction of altered outcome, then we have an independent test that strongly boosts our confidence. This method is embodied in the old proverb that "the exception proves the rule," although many people misunderstand the proverb because it refers to the less common meaning of "prove." Prove comes from the Latin *probare*, "to test" or "to try." Its usual, modern meaning refers to final and convincing demonstration and the motto would seem to say that exceptions establish indubitable validity. But in another sense, closer to its root, "prove" (as in "proving ground" or printer's "proof") is more like its cognate "probe," a test or an exploration. It is the exception that probes the rule by



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Fortunately, nature has been profligate in providing species and modes of life that violate the premises of Fisher's argument. In 1967, British biologist W.D. Hamilton (now at the University of Michigan) gathered the cases and arguments into an article entitled "Extraordinary Sex Ratios" (*Science*, April 28, 1967). I will discuss in this column only the clearest and most relevant of these probing violations.

Nature rarely heeds our homilies in all cases. We are told, and with good reason, that mating of brothers and sisters should be avoided, lest too many unfavorable recessive genes gain an opportunity to express themselves in double dose. (Such genes tend to be very rare, and chances are small that two unrelated parents will both carry them. But the probability that two sibs carry the same gene is usually 50 percent.) Nonetheless, some animals never heard the rule and indulge, perhaps exclusively, in sib mating.

Exclusive sib mating destroys the major premise of Fisher's argument for one to one sex ratios. If females are always fertilized by their brothers, then the same parents manufacture both partners of any mating. Fisher assumed that males and females had different parents and that an undersupply of males awarded genetic advantages to those parents that could produce males preferentially. But if the same parents produce *both* the mothers and fathers of their grandchildren, then they have an equal genetic investment in each grandchild, no matter what percentage of males and females they produce among their children.

In this case, the reason for an equal balance of males and females disappears and the previous argument for female predominance reasserts itself. If each pair of grandparents has a limited store of energy to invest in offspring, and if grandparents producing more offspring gain a Darwinian edge, then grandparents should make as many daughters as possible, and produce only enough sons to insure that all their daughters will be fertilized. In fact, if their sons can muster sufficient sexual prowess, then parents should make just one son and use every bit of remaining energy to produce as many daughters as they can. As usual, bountiful nature comes to our aid with numerous exceptions to probe Fisher's rule: indeed, species with sib mating also tend to produce a minimal number of males.

Consider the curious life of a male mite in the genus *Adactylidium*, as described by E.A. Albadry and M.S.F. Tawfik (*Annals of the Entomological Society of America*, 1966, p. 458). It emerges from its mother's body and promptly dies within a few hours, having done apparently nothing during its brief life. It attempts, while outside its mother, neither to feed nor to mate. Now we know about creatures with short adult lives—the mayfly's single day after a much lengthier larval life, for example. But the mayfly mates and insures the continuity of its kind during these few precious hours. The males of *Adactylidium* seem to do nothing at all but emerge and die.

To solve the mystery, we must study the entire life cycle and look inside the mother's body. The impregnated female of *Adactylidium* attaches to the egg of a thrip. That single egg must provide the entire source of nutrition for generating all her offspring, for she will feed on nothing else before her death. This mite, so far as we know, engages exclusively in sib mating; thus, it should produce a minimal number of males. Moreover, since total reproductive energy is so strongly constrained by the nutritional resources of a single thrip's egg, progeny are strictly limited, and the more females the better. Indeed, *Adactylidium* matches our prediction by raising a brood of five to eight sisters accompanied by a single male who will serve as both brother and husband to them all. But producing a single male is chancy; if he dies, all sisters will remain virgins and their mother's evolutionary life is over.

If the mite takes a chance on producing but a single male, thus maximizing its potential brood of fertile females, two other adaptations might lessen the risk—providing both protection for the male and guaranteed proximity to his sisters. What better than to rear the brood entirely within a mother's body, feeding both larvae and adults within her, and even allowing copulation to occur inside her protective shell. Indeed, about forty-eight hours after she attaches to the thrip's egg, six to nine eggs hatch within the body of a female *Adactylidium*. The larvae feed on their mother's body, literally devouring her from inside (much like the gall midges I discussed in December 1976). Midges are insects, but mites belong to a different group (Acarina) within the phylum Arthropoda. Thus, the similarities of rearing are convergent; they reflect separate evolution, not common descent.

Two days later, the offspring reach maturity, and the single male copulates with all his sisters. By this time, the mother's tissues have disintegrated, and her body space is a mass of adult mites, their feces, and their discarded larval and nymphal skeletons. The offspring then cut holes through their mother's body wall and emerge. The females must now find a thrip's egg and begin the process again, but the males have already fulfilled their evolutionary role before "birth." They emerge, react however a mite does to all the glories of the outside world, and promptly die.

But why not carry the process one stage further? Why is the male born at all? After copulating with his sisters, his work is done. He is ready to chant the acarine version of Simeon's prayer, *Nunc dimittis*—"Lord, now lettest thou thy servant depart in peace." Indeed, since everything that is possible tends to occur at least once in the multifarious world of life, a close relative of *Adactylidium* does just this. *Acarophenax tribolli* also indulges exclusively in sib mating. Fifteen eggs, including but a single male, develop within the mother's body. The male emerges within his mother's shell, copulates with all his sisters, and dies before birth. It may not sound like much of a life to us, but the male *Acarophenax* does as much for its evolutionary continuity as Abraham did in fathering children into his tenth decade. Nature's oddities are more than good stories. They are material for probing the limits of interesting theories about life's history and meaning.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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# Sacred Dances of Bhutan

*An ancient tradition of festival drama*
*is the protective ritual of a Buddhist kingdom*

**by Michael Aris**

By chance, the first two British political missions to reach the remote kingdom of Bhutan in the eastern Himalayas, in the years 1774 and 1783, arrived at the time of the annual *Dromchö* festival held in the summer capital at Thimphu. "The whole together presented a collection of more fiendlike visages than ever painter represented in the temptation of Saint Antony, and the wild and clamorous sound of the instruments seemed well adapted to make such devils dance," wrote one of the observers, recording the first Western contacts with a rich and complex tradition, which later travelers discovered thriving in all those regions throughout Asia where Northern (Tibetan) Buddhism, or Lamaism, prevailed. Failing to understand this tradition in the context of history and Buddhist doctrine, the early observers were baffled by what appeared to be a macabre and sinister spectacle. They could not appreciate its significance for the Bhutanese peasants who watched the dances (*cham*) against the magnificent backdrop of temple or fortress.

Bhutan is today the only independent country where Northern Buddhism survives as the state religion. The performance of sacred dance as a state ritual by trained monks and laymen in the national and provincial capitals has all the support of the government and royal family. At the same time, quite independent of official patronage, several festivals of sacred dance take place in local temples and monasteries in Bhutan, just as they do in other Himalayan regions untouched by Communism from the north, reminding us that the whole tradition has its origins in a private, indeed secret, initiatory experience that has nothing to do with governments.

How do we explain the basic paradox of dance in a religion whose most powerful symbol is the Lord Buddha sunk in concentrated immobility, a religion that has always prohibited music and dancing for its ordained disciples. The answer is found in the whole development of Mahayana ("greater vehicle") Buddhism, which saw the incorporation of many ritual and meditative techniques belonging to older, non-Buddhist traditions. If these could be adapted to the Buddhist aim of escaping from the round of phenomenal existence by severing the root of the "self," then they were easily validated and absorbed under the heading of "skillful means."

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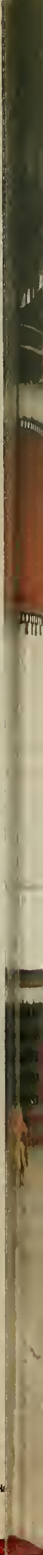
This process partly accounts for the presence of large sections of the Hindu pantheon in Northern Buddhism and for the survival of many pre-Buddhist deities of specifically Tibetan origin, all with their primary characters more or less neutralized in the interests of the nontheistic nature of Buddhism. These myriad sets of gods and their attendants acquired a supportive role, interpretable on several different levels of reality. Ultimately, they were seen to arise from, and dissolve back into, the universal matrix of the "Void." It became the meditator's task to identify himself with a deity to such a degree that he realized in himself this process of creation and dissolution, thus freeing himself of its mastery and the perverted view of reality that marks human existence.

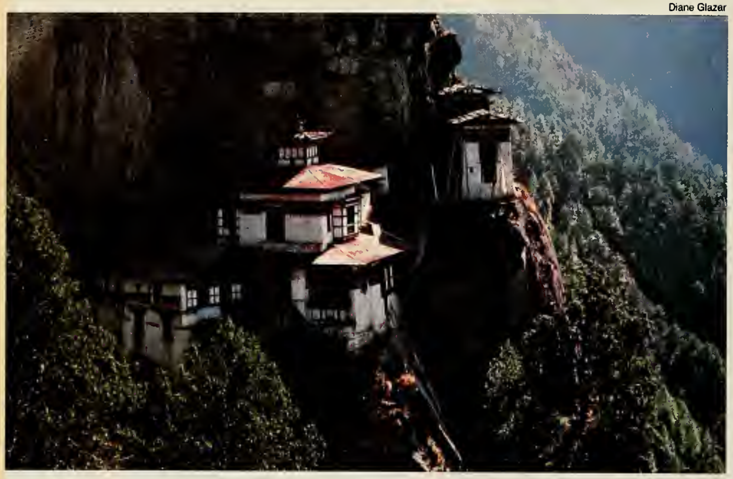
The deity that is made the object of meditation is usually the one associated with the meditator's particular school of Buddhism or the one favored by his own teacher, although in some cases it can be a matter of individual choice. One of the principal ways of achieving union with the chosen deity is through the repetition of a mantra, a string of syllables that contains the deity's essence, while at the same time visualizing the form of the deity in the center of a mandala, a diagram of the deity's heaven as it is conceived to



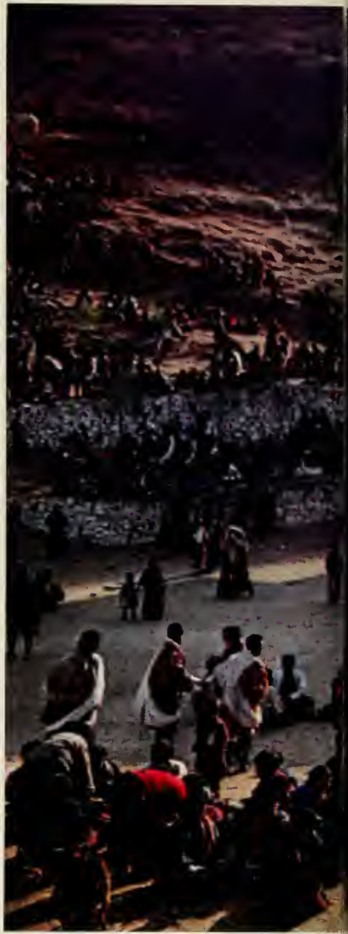
*While the ritually important dances are the domain of monks versed in the sacred tradition, trained laymen, right, perform many of the auxiliary dances featured in national and local festivals.*

Ernst H

Diane Glazer



The Tagtshang monastery in Paro, above, is associated with the deified Indian sage Padmasambhava, who, according to legend, introduced Buddhism to Bhutan and Tibet. It is in his heaven that some of the sacred dances are supposed to have been revealed to their composers, who traveled there in a dream or trance. Right: Padmasambhava is depicted in the *T'ongdröl* tapestry in Paro, believed to offer enlightenment to those who view it.



exist both within and outside the body of the meditator. The initiate supplements these verbal and mental exercises by taking on the physical attributes of the deity as expressed in a mudra, a code of gestures that likewise summons the essential nature of the god. The deity in his heaven is often conceived as performing a divine dance, and there seems little doubt that dancing as the god incarnate originated as one of the secret experiences that those initiated into the esoteric traditions of Buddhism, the tantras, had to learn from their master. The Hevajra Tantra explains:

> Dancing as Śrī Heruka with mindful
> application, undistracted,
> Meditating with thought impassioned,
> the mind uninterrupted in its
> concentration,
> Buddhas and masters of the Vajra-
> doctrine, goddesses and yoginis,
> Sing and dance to their utmost in
> this song and dance.
> There comes thereby protection for
> the troupe and protection for
> oneself. Thereby the world is
> reduced to subjection.

Among the cultural achievements of the Lamaist world, the origin and history of sacred dance are perhaps the least documented. There is as yet no means of knowing whether the tradition was transmitted from India by tantric masters or whether it arose spontaneously in Tibet in reaction to the written descriptions of heavenly dance contained in tantric literature. What is sure is that the performance of sacred dance as a public show only became part of monastic curriculum after a great deal of hesitation and some misgiving. Even today, the upholders of the tradition insist that the dances must not be performed as a worldly spectacle, and there are still a few monks and scholars who go so far as to decry the very nature of these rites.

For the great majority of religious practitioners, however, the dances are an indispensable part of certain annual rituals. They are a dramatic extension of the liturgy, constituting the "generation of the deity in front," that is, externally, which follows upon the "generation of the deity in oneself" accomplished as a ritual in the main temple by the assembled monks. Both stages, internal and external, revolve around the creation of the deity's mandala, a circumscribed area rendered safe from hostile influences into which the god is led by his divine attendants. In the liturgical ritual, the mandala is a painted, sometimes three-dimensional physical object. The main section of the dance, consisting of clockwise circular movements, echoes the formal structure of the painted mandala. This is preceded and followed by phases of creation and dissolution.

As portrayed in many dances, the deity is basically compassionate but has assumed a wrathful appearance to counter evil influences that cannot be subdued by peaceful means. The climax of most dances dedicated to the wrathful deities occurs when an effigy representing evil is stabbed and dismembered in an act of ritual murder. Sometimes this is realistically performed, with the blood-filled intestines of an animal extracted from a dough figurine and cast in all directions. The base nature of the evil power is thus

Michael Ans

annihilated, while the conscious principle is released to a heaven—until the following year.

On one level of interpretation, it is the "self" that is thus destroyed. The more usual view holds that what is destroyed are the forces opposing Buddhism in general or opposing a particular school of Buddhism. This belief helped to give the dance its place in state and community ritual. A whole cycle of Tibetan sacred dances known as the Black Hat, which is also very popular in Bhutan, is said to imitate the movements with which the Tibetan monk Pelgi Dorje sought to distract the anti-Buddhist king Lang Darma before assassinating him in A.D. 842. The Black Hat dances and all the other dances whose purpose is the destruction of evil are performed for the sake of the whole nation or for a particular district in annual festivals of renewal and rededication.

Two major streams can be discerned in the development of sacred dance; both are represented in the Bhutanese tradition. The first is mainly associated with the *Nyingmapa* ("old order") school, dating from the twelfth or thirteenth century. It depended on visionary revelations—a source now considered dormant—for the authority of the sacred dances. In a dream or trance the composer would travel to the realm of the deified Indian sage Padmasambhava, and on his return he would teach his disciples the heavenly dances he saw performed there. The second stream is associated more with the later schools, which sought to rubricate and codify those dances inherited from the older schools, including the *Nylingmapa*, that could be regarded as authentic in origin.

Both the revelational and codifying traditions depended on dance manuals (*chamyik*) to record the dances for posterity. These texts are never used for the purposes of practical study, however; they serve instead to remind the chief exponents in case of doubt. Separated from the living tradition of personal instruction, they are as incomprehensible as the notation found in Tibetan musical scores. Not only the steps of the dance but the whole process of meditative visualization has to be learned directly from a master (*champön*).

Certain mnemonic devices, such as counting out the rhythm, are employed to help the student memorize the complicated steps. If one considers that many festivals continue for up to six days with very few breaks, some idea is gained of this prodigious feat, yet it forms only one small part of the entire curriculum of study. A story found in the biography of the sixth Dalai Lama (of Tibet) tells how, as a boy, he had to watch his dance master perform in snow so that by observing his footprints he could memorize all the different "thunderbolt steps," a technique of study peculiar to the *Gelukpa* school at that time. The Dalai later chastised himself for having watched the performance merely as a show.

Long before Bhutan achieved its unification and independence in the middle of the seventeenth century, it had developed its own sacred dance traditions associated with the great saint Pema Lingpa (1450–1521), the ancestor of the present royal family. His autobiography contains several vivid passages describing the visions he had of the dances performed in Padmasambhava's heaven. Today, the extensive repertoire credited to Pema Lingpa has an auxiliary function in all the major festivals and never forms the principal item. His dances provide interludes before and after the ritual climax centering on the deity invoked in the mandala. Many of Pema Lingpa's compositions portray different sets of divine attendants and acrobats, who prepare a path to heaven.

Some of these dances have strong shamanistic overtones derived from a stratum of pre-Buddhist tradition centering on the village oracle and his state of possession or flight to heaven. Certain of Padmasambhava's divine attendants are known as *pawo*, the common name for the village oracle in Bhutan. An oracle, accompanying himself on the pellet drum, performs the steps of a snow cock before falling into a trance and receiving the god into his body. Pema Lingpa's ceremonial version of this rite has two pairs of heavenly *pawo* imitating the steps of the village oracle; the dance is commonly performed to welcome distinguished guests to a palace or fort, conceived here as a heaven.

The shaman's drum is also used in the Drum Dance of Dramitsé, attributed to Pema Lingpa's son Kunga Wangpo, who saw it in heaven and had it performed to consecrate a temple at Dramitsé in eastern Bhutan. As in the case of several other dances, the performers wear a variety of animal masks made of wood or papier-mâché. The strange spectacle can have a grace and dignity all its own even though there are no opportunities to depart from, or improvise on, its immutable form.

Sacred dance certainly had its place in the complex of emotions, ambitions, and reactions that were released in the quest for Bhutanese sovereignty. Although it had long been fragmented into a number of clan territories and ecclesiastical principalities, the country achieved unification despite the concerted opposition of successive Tibetan regimes. This was accomplished mainly through the efforts of the great monk and scholar-statesman *Shabdrung* Ngawang Namgyal, who arrived in western Bhutan as a refugee in 1616. Hereditary prince-abbot of the powerful *Drukpa* ("thunder dragon") sect of the *Kagyüpa* school (the school of "oral transmission"), he consolidated the *Drukpa* hold on the western region. His immediate successors extended the borders to their present limits, and after much difficulty, a theocracy was established, with the incarnations of the founding *Shabdrung* (Bhutan's equivalent to the Dalai Lama of Tibet) acting as titular heads of state. Temporal authority was delegated to the office of the *Druk Desi*. The British came to know the two incumbents as the *Dharma Raja* ("king of religion") and the *Deb Raja* ("regent"). (Both offices disappeared after the present hereditary monarchy became established early in this century, and the present *Shabdrung* incarnation does not reside in the country.)

The country was ruled from the huge capital and provincial fortresses (*dzong*) that dominate the major val-

*Performances by monks, below and right, became accepted ritual practice, despite the reservations of some Buddhist scholars. The royal dance troupe now on world tour, however, consists only of lay dancers.*

Ernst Haas

leys to this day. In these imposing structures were housed communities of state monks dedicated to the ruling *Drukpa* school, and many government officers were drawn from the country's large monastic population. Some rose from the ranks of the lay servitors, or retainers, attached to each *dzong*. Despite their lay status, they were required to observe a semimonastic code of discipline. The institutions developed under the theocracy penetrated to every region of the country and affected every facet of its subjects' lives.

The triumph of the ruling *Drukpa* sect (which ultimately gave the country the name used by the Bhutanese themselves—*Drukyul*) is traditionally ascribed to the sect's hold over its guardian deities and, particularly, to the intimate relationship that the founding *Shabdrung* is supposed to have had with them. How else, it is claimed, could the Bhutanese have repulsed no less than six Tibetan invasions during the lifetime of the *Shabdrung*, and many more thereafter. There is little doubt that *Shabdrung* Ngawang Namgyal himself used the destructive forces of sacred dance in acts of sympathetic magic directed against the enemy rulers of Tibet. One incident recalled in his official biography tells how he took the lead in a dance dedicated to the chief protective deity Mahākala. Waving a banner "like the black cloud blowing from the vault of the sky at the end of time," he danced to the center of the courtyard and there consigned to a triangular pit a list containing the names of his enemies, "so that he radiated a great brilliance which terrified all those who stood close by."

The Mahākala ritual later formed the basis of the New Year festival that is still held in the old winter capital at the fortress of Punakha. The masked dances, known as the *Punakha Dromchö*, last for five days, and their special feature is the formal role adopted by selected laymen from eight villages who act the part of a ceremonial militia, the successor of the *Shabdrung*'s personal army. They provide a scene of extraordinary medieval panoply, further enriched on the last day by a long monastic procession to the banks of the P'o-chu River. There, the head abbot in the costume of the Black Hat offers to the serpent spirits pieces selected from all the mandalas that have been consecrated by the monks throughout the year. The apparel of the abbot on that occasion reminds one of temple paintings that show the *Shabdrung* in his wrathful aspect performing a dance of destruction in the Black Hat costume.

The uncompromising figure of the founding *Shabdrung* looms over many of the Bhutanese sacred dances and the stories surrounding them. One typical legend tells how the Mahākala dance of the *Legön Tsokhor* happens to lack a finale: While providing appropriate accompaniment with cymbals from his throne, the *Shabdrung* once summoned a dancing emanation of this god to bring him the soul of the enemy ruler of Tibet, but the chief minister, who was peeping from behind a curtain, disturbed the god, causing him to disappear before the completion of the dance.

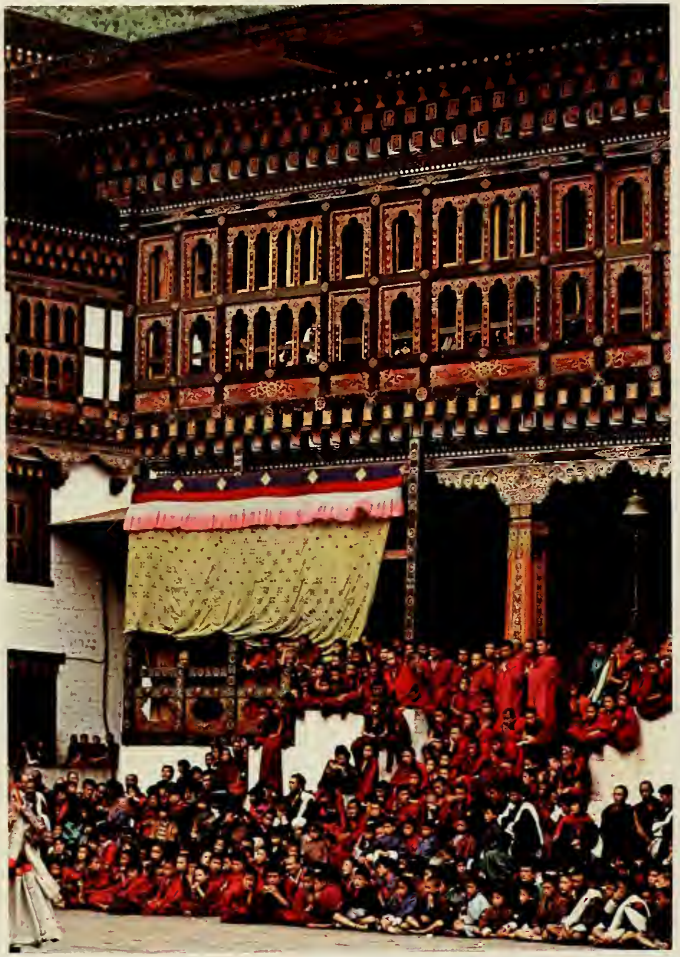
The festival of the *Punakha Dromchö* established by the *Shabdrung* as the official New Year celebrations of the government later served as a model for the summer festival introduced to the summer capital (now the permanent capital) at Thimphu. While the *Punakha Dromchö* centers on the deity Mahākala, the *Thimphu Dromchö* is appropriately dedicated to the god's consort, Śrī Devī ("glorious goddess"), and it ends with three days given over to the worship of the deified saint Padmasambhava, who has so many legendary associations with Bhutan. Underlining Padmasambhava's importance for the Bhutanese is the fact that in all the provincial fortresses and in several private monasteries, it is the dances dedicated to him that take up their festivals. Thus, while the capital region concerns itself mainly with protective rites to guard the state at large, the provinces turn to the more conciliatory figure of Padmasambhava and his eight aspects, all of whom appear robed and masked on the final day of each festival to give their blessings to the public. On occasion, gigantic appliquéd tapestries depicting Padmasambhava are raised to form an extraordinary backdrop. Objects of great devotion, they are known by the

Ernst Haas

*Overleaf: The Black Hat dances, performed to subdue evil, are said to imitate the movements with which the Tibetan monk Pelgi Dorje distracted an anti-Buddhist king before assassinating him in A.D. 842.*

Ernst Haas

Brian Wood



*Left: While festivals are enjoyable spectacles, those attending are also believed to receive blessings. Many dances are didactic in purpose; the dancers in* P'olé Molé, *right, enact a tale of marital fidelity.*

special term *t'ongdröl,* "liberation by sight."

Many of the auxiliary dances performed in the festivals are directed toward the edification of the audience rather than the achievement of a ritual goal. Today a professional touring group of trained laymen generally performs these dances, but previously the dancers were recruited from among the lay servitors attached to each fortress. Some of the richest and most interesting items from the Bhutanese repertoire belong to this category of "attendants' dances" (*böcham*), including all those attributed to Pema Lingpa outlined above.

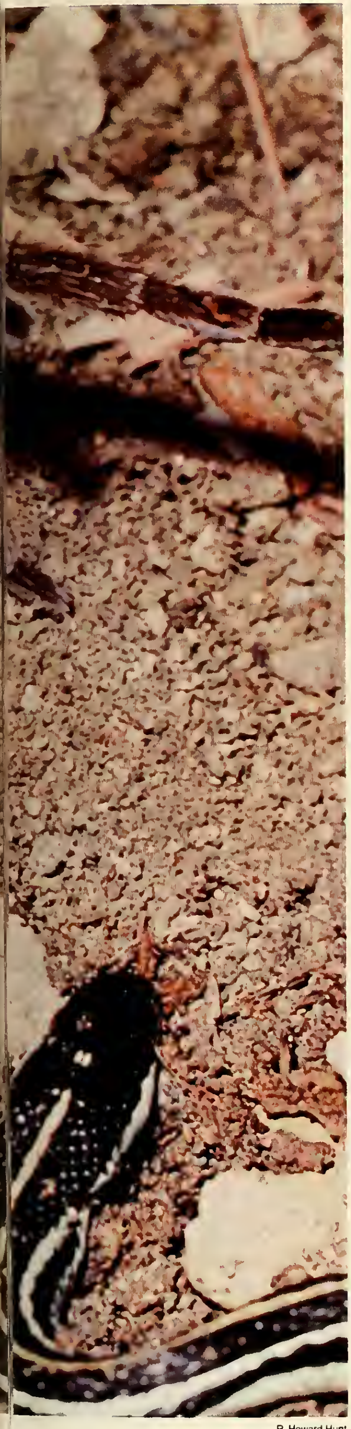
Most didactic in purpose is perhaps the Red Dance of the *Rakshas,* which derives from the same tradition as the famous Tibetan Book of the Dead. The Lord of Death presides over a court that judges a man for his past actions. His release from samsara, or future rebirth, is determined by how he reacts to the fearful apparitions who are the god's retinue, actually his own karmic projections. Another dance drama, whose purpose is to engender a feeling of faith and renunciation, enacts the story of how the poet-saint Milarepa (1040–1123) saved a deer from a hunter whom he subsequently converted to a life of religion.

On a more mundane level, the sung and mimed dance of *P'olé Molé* ("the good man and the good lady") is concerned with the virtues of marital fidelity and derives from a Tibetan tale that stems ultimately from an Indian tradition.

A poignant survival in this category of auxiliary dances is *Chözhé* ("dharma song"), the dance of the old monastic bodyguard of the *Drukpa.* It is supposed to be based on an incident in the life of the sect's founder when he countered the supernatural forces opposing him on his journey to open up the pilgrim route to the sanctuary of Tsari in southeast Tibet. The slow and stately gestures of stylized subjugation performed in perfect unison by laymen dressed as warrior monks seem to convey something of the essence of the Bhutanese tradition, which has always striven for harmony between its secular and spiritual ideals.

No performance is complete without a clown (*atsara*), whose business it is to provide light relief by ridiculing the sacred dances, performing obscene jokes, and acting as stagehand. He represents an aberrant figure who arose from the national subculture only to be absorbed by the traditional order. He is comic but at the same time deeply serious, for he stands ultimately for unity and balance. His mask and name show him to be an Indian teacher—a figure of fun because he is an Indian with a big nose, but sacred because he is a teacher.

Are the guardians of Buddhist orthodoxy shaking their heads dolefully in some distant heaven of pure dance as they look down on all these developments? In the Bhutanese experience alone, the presiding authority for sacred dance has filtered down a line stretching from tantric yogis to a reincarnating theocrat and thence to the hereditary Buddhist monarch of today. More and more folk elements and local cults have gradually been brought in, turning the spectacle outward toward the audience and away from its meditative core. Few dancers now achieve that perfect balance of body, speech, and mind that is said to be the prerequisite for sacred dance. But what remains is a vital and enriching experience, for while the dancers may know they are not gods, there still remain spectators who sometimes see their gods come alive. □



R Howard Hunt

# Toad Sanctuary in a Tarantula Burrow

*A snake that tries to make a meal of a tiny toad may have to face the fearsome defense of a huge spider*

**by R. Howard Hunt**

A western ribbon snake, its forked tongue flicking, slipped through boulder-strewn prairie grass hunting for prey. Abruptly, it paused at a limestone slab and began to flick its tongue more rapidly, sampling the air for the chemical cues that would tell it a toad was near. Nearby, a narrow-mouthed toad dipped and darted about a small hole from which a ceaseless stream of ants flowed. Its attention was riveted upon the hole and the delectable ants. Suddenly, a striped blur hit the nickel-sized toad, engulfing it almost instantly. As the ribbon snake's jaws enveloped the toad's entire body, the doomed animal kicked and struggled, but the quivering bulge moved farther and farther down until it was only a muscular ripple carrying the small morsel to the snake's stomach.

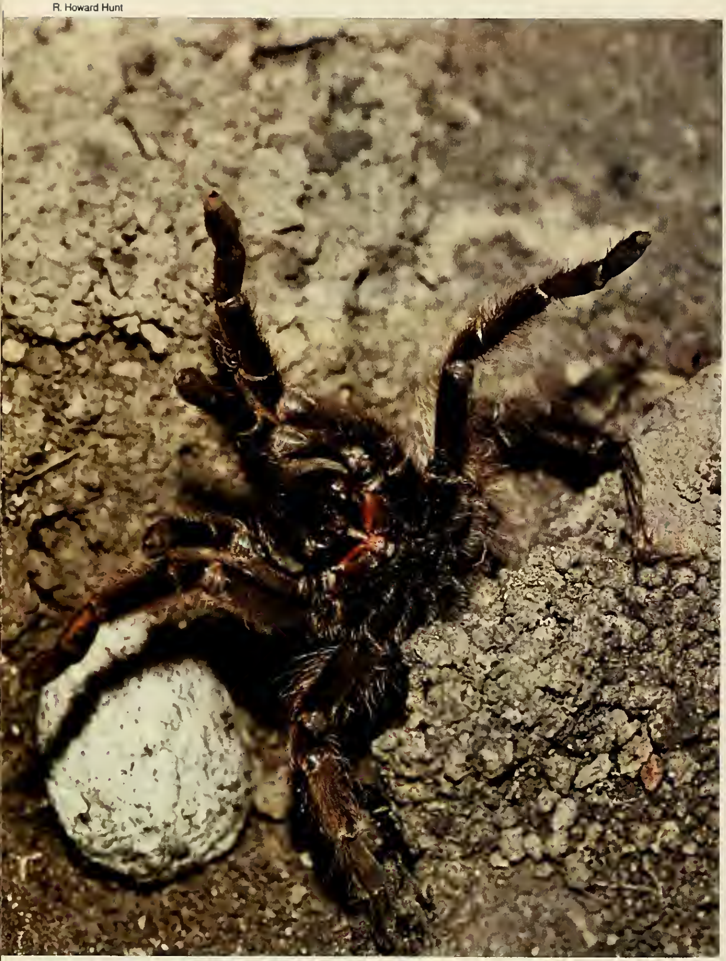
Undetected by the ribbon snake, a second narrow-mouthed toad hunched hard against one flat edge of the limestone slab. The toad had seen the approaching snake and had stopped dead still, its pointed snout pressed into the soil. But the sham did not work, for the snake again slithered forward toward the small, brown lump that was the toad. The lump stirred, then bounded to the only escape possible—a burrow beneath the slab.

Sensing another meal, the ribbon snake followed the toad's scent trail, which led to the entrance of the burrow. And just beyond, at the edge of darkness, crouched the toad. With lidless eyes fixed on its prey, the snake tensed for a lunge. Suddenly a great hairy body, propelled by eight hairy legs, burst from the depths of the burrow, and a fully mature, female tarantula scuttled to within an inch of the toad. Taking advantage of the situation, the toad fled to safety—beneath the imposing black fangs of the tarantula. The confused snake reversed itself and disappeared into the waving grass. Danger past, the narrow-mouthed toad *Gastrophryne olivacea* wriggled from under its burrow companion, the giant tarantula, *Dugesiella hentzi*.

In my youth, I tramped the grasslands west of Fort Worth, Texas, observing these fascinating mygalomorph spiders. One of my favorite haunts was a narrow tract of land crossed by a shallow creek and railroad tracks. Construction workers on the latter had ripped a vast number of 100-million-year-old limestone rocks from their bed and onto the flat prairie. When I spotted a likely rock, I flipped it over and often uncovered a startled

*At the approach of a western ribbon snake, a narrow-mouthed toad scuttles toward the safety of a female giant tarantula. Instead of a toad, the snake will get a faceful of spider feet and fangs.*

R. Howard Hunt



*A female tarantula will defend her egg case at any sign of disturbance. Normally aggressive, she is particularly ferocious while her eggs are incubating.*

tarantula, which instantly raised its fangs in a very threatening manner. I knew that *Dugesiella*'s weak venom presents no real threat to humans. At times, however, an annoyed tarantula displays another defense tactic: using its fourth pair of feet, it brushes irritating hairs from its dorsal abdomen. Festooned with barbs and reverse barbs, and nearly impossible to work out once embedded, these hairs hang in the air, close by the tarantula, waiting for the eyes, nostrils, and mouth of any audacious attacker. (Expended hairs are replaced during molting, when the tarantula splits out of its exoskeleton and emerges with a fresh skin.)

Considering the tarantula's irascible nature, I was all the more amazed when I found up to five western narrow-mouthed toads in the same shallow burrow with it. When I lifted the sheltering rock from a burrow containing both toads and tarantula, the toads dived under the spider, which assumed a threatening fangs-up posture. As the tarantula moved in response to me, so did the toads. Repeatedly, they squirmed and wedged beneath the shifting tarantula. The panic ended when I gently replaced the rock over the unlikely group.

After a ten-year absence from Fort Worth and the tarantulas, I returned in the spring of 1975, determined to learn more about the strange relationship between toad and tarantula. Intending to re-create in a laboratory situation what I found in the field, I collected several tarantulas, along with their associated rocks, soil, and toads. Under one platter-sized fossil ammonite, I found more than I had expected: six adult narrow-mouthed toads; the chitinous remains of pill bugs, millipedes, crickets, and beetles; an old tarantula egg case; the molt of an adult tarantula; a lizard skeleton; and a large female tarantula, measuring almost two inches from fangs to abdominal spinnerets. Although I usually assign numbers to study animals, I thought it appropriate to name this tarantula Ammonita, in honor of her unusual shelter. Returning to the laboratory, I reunited Ammonita with her toads in a terrarium, two by four by two feet deep.

Ammonita immediately started a burrow under the fossil. Working several nights like a minibulldozer, scooping out and carrying clods of earth with her versatile fangs, she excavated a spacious burrow six inches long and lined the entrance with silk. Fortunately for my observations, the burrow had no bends or obstructions, and with the aid of a penlight, I could see its entire length.

As I had hoped, the toads moved in with Ammonita and soon a routine developed. In the evenings, the tarantula waited motionless at the mouth of the burrow, ready to snatch a passing insect, and one by one the six toads brushed by her and skulked around the periphery of the fossil. Once or twice a week, Ammonita satiated her modest appetite with a single cricket or beetle, which she quickly reduced to a sticky pellet between her fangs. The toads, however, required seemingly infinite amounts of termites and ants; on one occasion a tiny male lapped up twenty fire ants within five minutes.

Because of its tough and toxic skin, a narrow-mouthed toad can wallow freely among ants. But the distasteful skin does not repel all snakes: the western ribbon snake, *Thamnophis proximus*, can devour a dozen toads in short order.

One evening, I released a twenty-inch ribbon snake into Ammonita's terrarium. As usual, the tarantula stood at the entrance of her burrow, and the toads foraged nearby. The snake soon neared the burrow, but the toads hopped toward their protector and the tarantula held her ground. At the moment of truth, only one toad remained under Ammonita, the rest having fled to the innermost recesses of the burrow. With one back foot resting lightly on the head of the toad, Ammonita slowly raised her fangs. The snake, evidently sensing no danger in this, crawled closer to the entrance, then tried to inch past Ammonita. Suddenly, the tarantula jabbed with feet and fangs. Startled, albeit uninjured, the snake sped out of the burrow and away from the thing lurking within.

In July, I gave Ammonita a mate, and a handsome one at that: he had splendid long legs, an auburn abdomen, and on either side of his gracefully curved fangs, a club-shaped pedipalp. At the tip of each pedipalp, a mature male tarantula possesses a bulblike syringe containing microscopic, sperm-packed capsules. This sexual structure develops after the last molt and signals an end, usually within months, to the male's life span of one decade. But before dying, he abandons his sedentary life and wanders far afield searching for a mate.

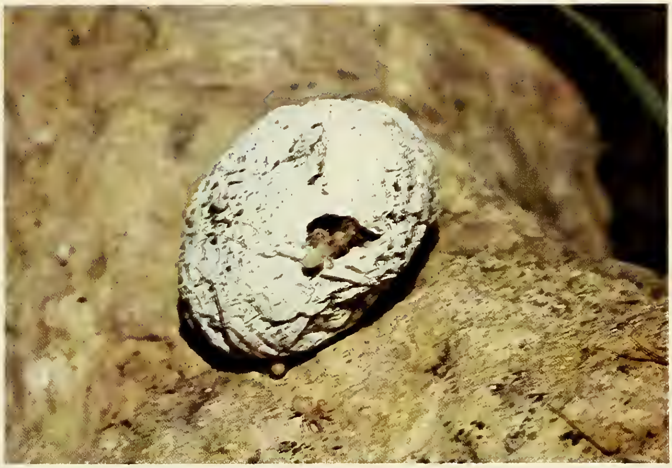
In his investigation of the terrarium, Ammonita's mate-to-be passed the silk-swathed hole beneath the fossil. His feet touched the silk and jerked spasmodically; his pedipalps rapped against the hard soil. Ammonita rushed him. He held her off by locking the hooks on his first pair of legs into her fangs and forced her into a nearly vertical position. Working rapidly now, he rhythmically brushed his pedipalps against Ammonita's sternum, then injected sperm into her genital pore. Immediately afterward, I removed the male to another terrarium where he quickly aged over the next several weeks. His movements became progressively feeble, and one entire leg dropped off at the joint. His purpose past, the male died one month after the mating.

But Ammonita continued lively as usual until October when she pushed soil across the entrance of the burrow until it was blocked. Soon the temperature in the unheated terrarium would cool to 45° to 50° F. The rate of metabolism of the poikilothermic tarantula and toads would then be reduced, allowing them to hibernate in the darkness of their sealed burrow.

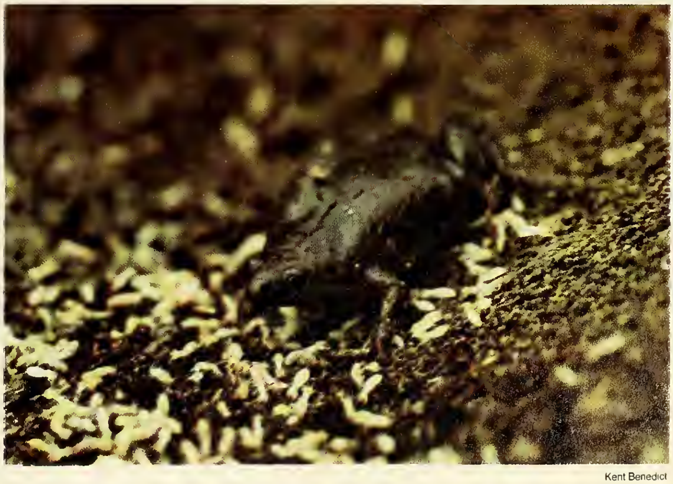
April 3, 1976. Ammonita and her toad companions emerged from hibernation. In the following weeks and months previous behavior patterns were renewed with one exception: Ammonita was even more aggressive when chasing introduced snakes. As usual, the toads had the run of the burrow; frequently, while moving about, they squeezed past her rapidly swelling abdomen.

May 31. Deep within the burrow, Ammonita began a silken bag that was to contain her eggs. She spun thicker

*Baby tarantulas begin to pour out of a hole they have ripped in the silken sack that has encased them for months, top. Hundreds of spiderlings are born at a time, after which they mill about their mother's burrow. Because their hairs are barbed, they have nothing to fear from their burrow cohabitants, the narrow-mouthed toads. In a terrarium experiment, bottom, termites were dropped into a tarantula burrow among the milling spiderlings. The toads preyed only on the termites and spit out any baby tarantulas that they inadvertently struck with their tongue.*



R. Howard Hunt



Kent Benedict

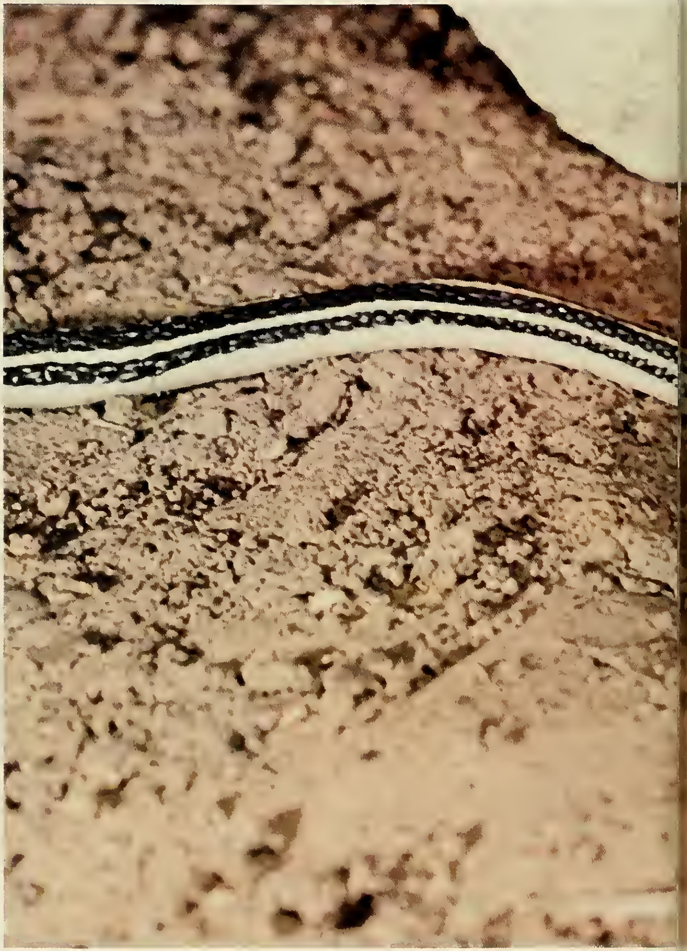
and thicker silk from her spinnerets onto the walls of the bag, and the following morning she hulked menacingly over the top of the completed egg case. But she still tolerated the toads, even when they squatted around the egg case or bumped it while pursuing termites and ants. I began to consider the possibility that the toads' ant-eating activities effectively reduced the numbers of this predatory insect in and around the burrow and thus provided a degree of protection for the egg case now and the baby tarantulas later.

Throughout the incubation period, the female tarantula periodically moved her egg case out to the warmth of sunlight streaming through a window and into the terrarium. Several hours later she hooked her fangs into a groove in the surface of the egg case and laboriously dragged it back into her burrow.

August 7. Hundreds of baby tarantulas poured from several small holes in the egg case. Most had already molted, changing in the process from all white to gray with a dark spot decorating their abdomens. Anxiously, I watched the toads hopping through the fuzzy carpet of tender young tarantulas clinging to the collapsed egg case and covering the back of the burrow. The toads appeared to take no interest in the tarantulas, which were approximately the same size as termites; I did not observe a single toad either stalking or eating a baby tarantula.

Thinking that even if the toads were not so crude as to immediately annihilate their protector's offspring and that they might accidentally ingest a baby in some kind of feeding frenzy, I dropped several dozen termites among the tarantula babies. One toad leaped into the writhing mass of termites and its stubby tongue punched out and claimed a soldier termite. Then others crept past baby tarantulas and stalked the rapidly dispersing termites. One large female toad had pushed her snout against a sluggish termite, when a baby tarantula suddenly scooted past the targeted termite and immediately found itself glued to a tongue and headed into the toad's mouth. But almost as quickly and much more forcefully, the toad shook the tarantula from her mouth—and I suspected why.

A microscopic check of scrapings from the abdomen of a baby tarantula revealed thousands of barbed hairs: the same hairs that serve adult tarantulas



*The snake is about to lunge at the toad huddled under the hulk of the tarantula. The snake is also about to meet the tarantula's fangs. The toad will soon be busily pursuing ants again.*

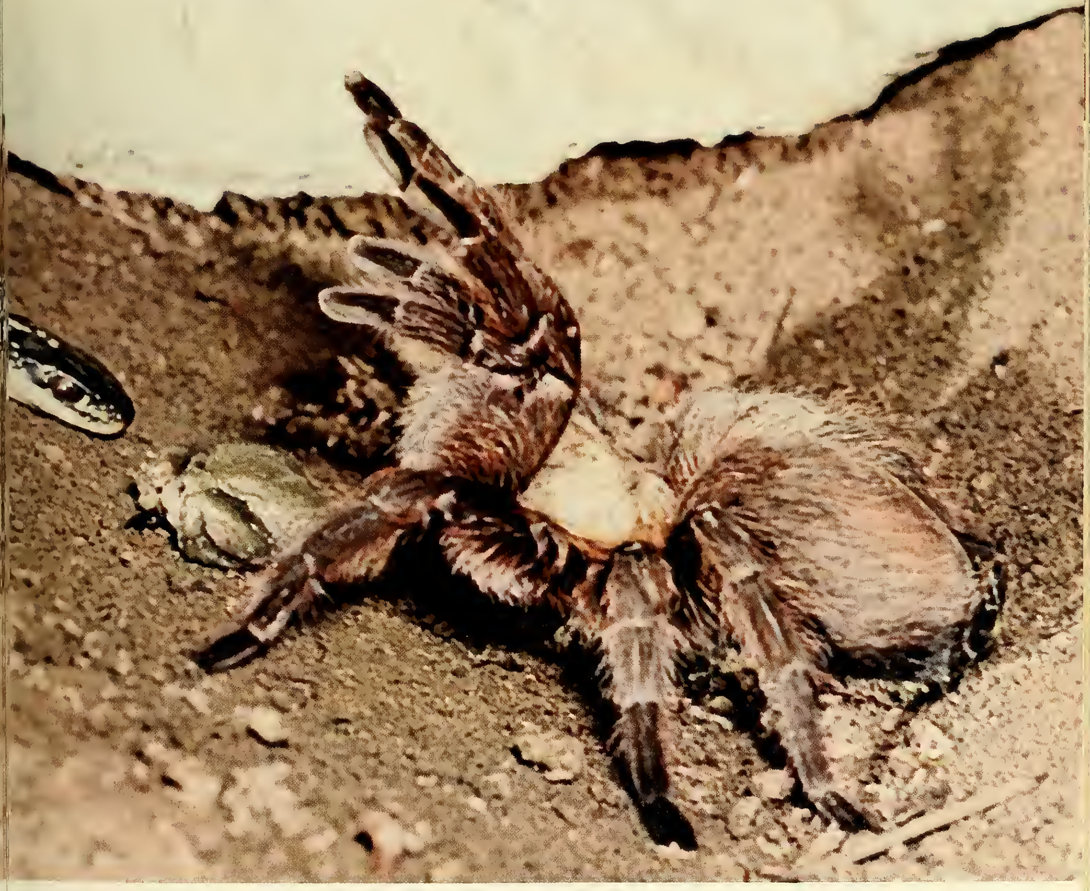
Kent Benedict

so well in repelling enemies apparently make youngsters unpalatable to the narrow-mouthed toads.

In the following weeks, the baby tarantulas dispersed throughout the terrarium, and once again Ammonita was alone in her burrow except for the toads. To test their loyalty and Ammonita's territoriality, I placed a half-grown female tarantula into the terrarium. The new resident excavated her burrow beneath a piece of shale. Before construction of this burrow, there had been an accessible space under the shale but the narrow-mouthed toads had rejected it as a home site. Now, however, two toads abandoned Ammonita and moved in with the young female who proved to be an excellent protector: each time an introduced snake poked its snout into her burrow, she forcefully evicted the trespasser. She began venturing farther and farther from her burrow during evening forays, and it was certain that soon she would meet Ammonita and a deadly struggle would result.

I knew the unequal contest had been fought when one fall morning I peered under the shale and found it vacant. Deep within the inner sanctum of her burrow, Ammonita stood over all that remained of her rival: several fragments of legs, a shredded cephalothorax, and two glistening fangs. Scattered around the chaotic pile of tarantula parts and snapping up ants that had been attracted to the carnage were all six narrow-mouthed toads.

As one male toad ducked under Ammonita and she touched him with a foot, I marveled at the interaction between these two dissimilar creatures. In its association with tarantulas, the narrow-mouthed toad has evolved an effective defense against the pressures of predation. The tarantula's fierce defensive behavior excludes most of those predators of a size dangerous to the diminutive toad, and the microhabitat of the burrow and overlying rock attracts small insects, providing a ready source of prey for the narrow-mouthed toads. And, with their appetite for ants, several toads per burrow can control these voracious invaders, which might otherwise harass adult tarantulas and consume eggs and spiderlings. The relationship between narrow-mouthed toads and tarantulas merits further study in all parts of their common Kansas, Missouri, Arkansas, Oklahoma, and Texas ranges. ☐



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# Downtown Deer

*It's hard for a predator to snatch a mule deer on someone's front porch*

**by Valerius Geist**

Just north of Glacier National Park, hard by the border of the United States and Canada, lies Waterton, Alberta, a small settlement dating back to the days when the surrounding land served as a game sanctuary. In 1932, the area was designated the Waterton-Glacier International Peace Park to commemorate the many decades of good neighborliness enjoyed by the two countries. The Waterton of today, like other resort towns in the Canadian Rockies, follows the rhythm of the seasons. In summer it is alive with the hustle and bustle of visitors, and motels, cafes, and service stations do a thriving business. In winter, silence descends, many buildings are boarded up, the golf course is deserted, the big, castlelike hotel on the hill overlooking the valley is empty of humans, and most roads are barricaded. The town is hibernating until the next summer. All this is little call to distinction since all resort towns have a cyclic life, but a visit to Waterton, preferably in fall, soon makes one aware of another element that gives the town a special character. Waterton is home not only to people but also to a population of mule deer.

On my first visit, years ago, I had barely entered the town when I saw a large mule deer buck resting on a porch. He ruminated contentedly and eyed the people on the street; only the tourists stopped. To the residents the deer are old hat. Beside the porch stood another buck, calmly performing—as is the way of mule deer—a marking ceremony. A few houses down the street, two other deer were grazing the lush, well-fertilized lawns. And so it went. In the back alleys the mud was marked with a mixture of deer and people tracks, and the campground's large lawns served as an evening and morning rendezvous for a big group of mule deer. Deer rested in front of the church and reluctantly made way for worshipers.

In the morning when schoolchildren were on the road and deer were most active, the happy state of coexistence was most evident. It was even rare for a youngster to make a snowball and heave it at a deer. Typically, the children did what children do, and the deer did what deer do, and when a big rutting buck passed children on one side of the road, none paid any attention to it. The citizens of Waterton had learned to live with deer. Some neophytes still struggled to plant gardens and grow some ornamental bushes, but the deer crossed any fence at will. A few homeowners hung strips of metal on some sacred little conifers they had planted, hoping that the deer would be spooked by the rattling tin. Indeed, when the bucks horned these little trees, the metal clanked loudly, adding to the din made by antlers breaking branches and stripping bark. I saw one indignant woman rush out and, with a broom, land a resounding whack across the big bottom of a large buck that was demolishing one of her trees. Slightly ruffled, the old fellow jumped off a few paces, shook his head, waited until the woman returned to her house, then resumed destroying her trees.

For as long as anyone can remember, deer have always been a part of Waterton. Every Sunday in winter, visitors come from the surrounding

*Mule deer wander calmly through the yards of people's houses in the town of Waterton, Alberta. Wind often blows the snow off lawns, making ample forage available during the winter months.*

Robert Peterson, Time

*Few ornamental conifers or shrubs of any kind escape the depredations of mule deer resident in Waterton. What plants are not eaten or trampled are often horned by the males, as the buck in the photo below is doing. Horning can be a means of communication between bucks and results in broken branches and stripped bark.*

Erwin A. and Peggy Bauer

towns to watch and feed the deer. Waterton's cats live insecure lives, constantly on the alert to avoid deer, for an unwary cat is quickly treed or chased into a house or woodpile by deer. From the deer's point of view, the town is an ideal place to be: coyotes and mountain lions, which readily kill deer elsewhere, do not enter the town; the lawns and shrubbery provide a seasonal, rich food source; and the houses and hedges not only grant shelter from the frequent high winds but also generate powerful vortexes that remove snow around houses, allowing deer access to green forage. While some people are a nuisance, disturbing the deer with their constant approaches to watch or photograph them, they are pests that the deer have long learned to tolerate.

Mule deer in Waterton have become extraordinarily tame and do not lose their tolerance, even in summer when they are dozens of miles away from human settlements. I have sat with mule deer bucks in their subalpine summer range or followed them step by step for miles, approaching to within feet to see more clearly what they feed on or to inspect the texture of their velvet antlers or the extent and nature of wounds they have incurred.

All this is in sharp contrast to the behavior of the closely related white-tailed deer. While I have often followed some fifteen to fifty paces to the rear of a mule deer buck for the better part of a day to study its behavior, I found only one white-tailed buck that did not object. Even following that buck was not very fruitful since other white-tailed deer spooked at our approach. White-tailed deer are common in the park but they remain shy. I saw them mainly at dawn and dusk or when I came upon them accidentally in cover. In some sanctuaries, white-tailed deer do learn to tolerate people, but I have never seen them acquire the mule deer's degree of tolerance. Why do two anatomically similar deer species, related so closely that they produce viable, albeit sterile, hybrids, act so consistently different?

Both mule and white-tailed deer are rather primitive New World deer, a branch of the family that has evolved in North America for some thirty to forty million years. New World deer have primitive dentition and feet. Compared with Old World deer, they have lower-crowned cheek teeth and larger phalange bones in their legs. They are adapted for movement over soft ground or uneven terrain; the extreme adaptation of this type is found in caribou, whose hoofs are modified for traveling on snow crusts and bogs, as well as for climbing on rocky ridges and talus slopes. As in other lineages of mammals, deer in warmer latitudes are more primitive than forms adapted to tundra, taiga, and periglacial regions. The whitetail was originally subtropical, with a preferred habitat of patchy dense bush and wet plain covered with tall grass. It has radiated widely and now occupies a variety of habitats. The mule deer is a recent offshoot of the same genus, but adapted to slopes, rocks, deserts, and mountains.

In comparison with mule deer behavior, white-tailed deer appear not only consistently more "nervous" but also far more expressive in their communication. The two species have an almost identical repertoire of social signals, quite different from those of Old World deer, but the difference in expressiveness is noticeable in all social communication, from simple to complex acts. For instance, both mule and white-tailed deer extend a courtesy to conspecifics when grazing in a

K ind Donna Dannen, Photo Researchers

Robert Peterson, Time

*The residents of Waterton have become blasé about the presence of mule deer in their town. Some gardeners still object to the deer's eating habits, but even a whack with a broom will not discourage a buck from making a meal of a bush.*

group. When passing another, however, a mule deer tends to lower its head; a whitetail not only lowers its head but also extends its nose and crouches noticeably. In full submissive behavior, a mule deer doe crouches slightly, spreads her legs, pinches in her tail, depresses her back, and keeps her head high; a white-tailed doe, in contrast, lowers herself almost completely to the ground, extends head and neck, and moves off through the grass.

Nowhere is the difference in expression better seen than in the sparring matches of bucks, a ritual highly developed in both species. Sparring matches occur only between bucks of different dominance rank, that is, between individuals whose rank disputes have already been settled. In mule deer, the larger buck solicits sparring matches by approaching a subordinate, but no match begins until the subordinate responds (except between two bucks who have a long sparring relationship). When soliciting, a dominant approaches in a weak dominance display, intercepts and tilts its antlers in front of the subordinate. If it accepts the gesture of the dominant, the subordinate moves forward, engages antlers, and begins the match. The subordinate also breaks the contact by jumping back. At this moment both bucks look up and avert their eyes from each other for a few seconds. Often the smaller buck will then tilt its antlers toward the dominant, which responds and another bout of sparring ensues. These matches can last in excess of half an hour and are different from the rare dominance fights between bucks of equal size and status. Sparring matches have a distinct sporting flavor and do not lead to settling of rank; dominance fights, by contrast, are dangerous combat in which contested ranks are resolved.

The sparring matches of white-tailed deer contain the same elements, but their execution differs. In response to the soliciting dominant, a subordinate white-tailed buck crawls on its belly to the dominant, licks its face, and then slowly rises and engages with its antlers. The smaller buck may also evade the larger by crawling on its belly toward the rear of the larger male and looking up at him in the process. He may also repeatedly sniff the tarsal scent glands of the larger buck.

The responses of female mule and white-tailed deer to courting bucks also show interesting contrasts. Females of both species move off when a buck attempts to court them. The mule deer female trots forward and circles back, with her head held low; her circle forms a diameter of some five to ten paces across, thirty to fifty paces if she is hard pressed by the buck. The female white-tailed deer also circles. Head low, she bolts from the buck and gallops off in a circle some two hundred to four hundred paces in diameter.

Mule deer are relatively inexpressive in their behavioral signals. At times, however, they act as if they had to overcome a high resistance in other mule deer in order to be noticed. Compared with the whitetail, the mule deer is more conspicuously colored, noisier, and smellier. When bucks horn shrubbery they do so loudly and usually for long durations; in fact, they use horning as an orientation signal. When

Robert Peterson, Time

*Visitors from other towns are not blasé about the "downtown deer." They flock to Waterton in winter to watch and feed the deer. Caution should be used in feeding the animals, for a deer expecting a handout may strike out with a hoof.*

two large bucks are out of sight of each other, each listens in the direction of the other's horning. They then move to meet each other. To advertise their dominance, big bucks urinate on their tarsal glands, special glands on the inside of their hocks; the larger the buck, the more it urinates on its hocks and rubs them together. The hind legs of a rutting mule deer buck tend to be matted with urine; those of a white-tailed buck are less soiled.

For effective communication, a message may have to be repeated a number of times. In addition to such repetition, an exaggeration of the message may be necessary to crash through the resistances of the intended audience. Mule deer social behaviors are also often punctuated by "crashing through" signals, akin to what physiologists call rebound. (A nerve cell, held back from firing, will respond excessively, or rebound, when released from inhibition.) The courtship behavior of mule deer illustrates these methods of communication. Normally, the buck, his head held low, approaches a doe from the rear, calls softly, and averts his eyes. His facial markings closely resemble those of a newborn fawn, and his courtship call is similar to a fawn's suppressed distress call. In essence, he plays "baby" to get close to the female and to make her urinate. Once she urinates, the buck tests the urine to ascertain her state of estrus.

A doe does not always urinate in response to this type of courtship. Urine is her sole means of stopping and getting rid of an excessively eager buck, so wasting the liquid would not be in her interest. When the "baby courtship" fails, the buck takes a different tack. He stiffens and his nose begins to twitch; he emits a long, thin moan, and females around him become noticeably tense. With a roar, he pounces at the courted female, slaps the ground with his hoofs, and gallops off after the departing female, roaring with each bound and slapping the ground. The chase may go on for a quarter of a mile. Suddenly the buck stops, the female stops—and urinates. During this "rush courtship," a big buck acts as if all inhibitions have been shed, and he becomes a roaring fury.

A white-tailed buck, by comparison, does not exhibit the baby courtship. He normally approaches a female with a weak rush courtship, slaps the ground once or twice, coughs a few times, then gallops silently after the female. The precopulatory courtship of the white-tailed buck is brief compared with that of the mule deer and copulation is a quick affair. In mule deer, the male initiates copulation with a series of mounts, usually six to ten, but sometimes in excess of forty. In whitetails, such precopulatory mounts are rare. After copulation, female mule deer show abdominal contractions, which can continue for up to an hour. Such contractions quickly cease or are absent in the white-tailed doe. Also, judging from the fights that I witnessed, those of mule deer bucks are more furious than those of white-tailed bucks.

All this illustrates that mule deer have a calm disposition which is shattered only occasionally, permitting the animal to act excessively. This calmness pervades almost all of their biology. Mule deer probably manage their stock of energy more efficiently and live longer than the excitable whitetail. They have a slightly higher life expectancy and are slightly less fecund than whitetails. The reason why calm mule deer and nervous whitetails have evolved appears to lie in their predator escape strategies.

In social interactions where mule deer run after one another, such as during play or when a buck runs after a doe, they do so at a fast gallop, low over the ground. That is, they run like white-tailed deer. When mule deer are alarmed by a predator, however, they attempt to escape by bounding in peculiar, high-arching jumps, as if jumping on a pogo stick. This bounding gait sacrifices speed for height. Thus, rather than speeding up when escaping a predator, a mule deer slows down.

The whitetail often responds to danger by hiding in cover and remaining tense and motionless. This behavior would not be adaptive unless coupled with a quick getaway when the deer is detected by a predator. The whitetail's getaway is signaled by an explosive motion, like the outburst of a covey of flushed partridges. Then the whitetail gains speed in an attempt to put as great a distance between itself and the pursuer as possible. The escaping whitetail uses every means at its disposal to maximize speed, such as avoiding obstacles by running along familiar trails, following the fresh trails of other deer, and running downhill. It confuses pursuers by running into water or by crossing the trails of other deer, leading the predator on a rally run. The hiding and lightning-fast

*Sharing an area with humans seems related to the mule deer's predator escape behavior. A "calmness," as the author calls it, marks the species' response to an approaching predator. The calm is reflected in other behaviors of the deer and may account for their tameness. In contrast, the more "nervous" whitetails do not enter Waterton.*

Erwin A. and Peggy Bauer

*In the intense courtship of mule deer, below, a buck harasses a doe to get her to urinate. By testing her urine, he can determine her state of estrus. Sparring matches between bucks, right, are held between a dominant and a subordinate and do not affect status. Dominance fights between deer of equal size can be fierce and dangerous.*

escape are hallmarks of an excitable, nervous animal.

When trying to escape from a predator, a mule deer does not avoid obstacles; on the contrary, it heads for obstacles, in particular, steep slopes. With its high-arching bounds, it can easily clear obstacles and can do so in a zigzag fashion. A mule deer can bound rapidly uphill, imposing a prohibitive energy cost on a pursuer attempting to follow at equal speed. The bounding appears to have a function beyond that of permitting rapid uphill ascent or clearing of obstacles: it also allows a closely pursued deer to move in an unpredictable direction. That is, as the predator lunges at the deer, the deer accelerates upward and lands on a spot that cannot be predicted. Such evasive tactics are successful only if a targeted prey jumps out of the predator's reach at the very last possible moment. If the prey jumps too soon, the predator can reorient; if it jumps too late, it is killed. A calm, unexcitable individual is better equipped to judge when to jump. Thus calm, unexcitable mule deer appear to be a product of one of their predator escape strategies.

Classical ecological theory has made biologists look at differences in food habits of coexisting species. This approach has not been very successful, however, in explaining ecological differences between mule and white-tailed deer since their food habits are quite similar. What escaped the biologists' attention was that security is of prime importance to an animal faced by many predators. Thus, focusing on antipredator strategies and the tactical requirements that make them successful has made me see a landscape inhabited by mule deer and whitetails differently from how I had seen it before. Not food, but the tactical requirements maximizing security appear to be the best predictors of the whereabouts of mule and white-tailed deer.

The success of mule deer today may be an artifact of modern times, in particular the absence or scarcity of efficient predators. Their tameness, however, and their willingness to share with people the same general residential areas, particularly in national parks, seems an accidental consequence of their ways of escaping predators. We can enjoy them there, but it does not pay to get too close. Some will come for handouts and strike with a sharp front hoof if they fail to receive the expected cookie. ☐

Erwin A. Bauer

# The High Importance of the Lowly Krill

*This small crustacean, crucial to the antarctic food chain, is threatened with possible overharvesting by humans*

### by Mary A. McWhinnie and Charlene J. Denys

Until very recently, Antarctica was most familiar as the great white continent surrounding the South Pole, populated primarily by seals and those delightful members of the avian world, the penguins. To anyone interested in ecology, Antarctica is also the area where fur seals were hunted to near extinction. But a ban on sealing has allowed them to recover. The ocean encircling the continent is, in addition, familiar as the scene of the demise of great numbers of baleen whales during the whaling industry's heyday.

Now, world attention has turned to a much smaller antarctic creature, the shrimplike crustacean *Euphausia superba*, commonly called krill. It is one of about eighty-six species of euphausiids, which are found in all of the world's oceans, but it is the only species properly called krill and the only one that has generated much scientific and economic interest. Although krill are relatively small—an adult animal may reach a maximum length of about 2.36 inches—their role in the antarctic ecosystem is pivotal. Krill are a primary food source for almost all higher species in the Antarctic—baleen whales, seals, penguins and other birds, fish, and squid. In fact, the yearly southerly migration of baleen whales to these waters to feed on krill during the austral summer was what made the Antarctic Ocean such a profitable hunting ground for whalers. The food reserves built up by the whales during their summer krill-feast sustained them to a great extent throughout most of the rest of the year in more northern waters.

Krill have a remarkably high protein content, approximately 50 to 60 percent of their dry weight. Their nutritional value compares favorably with other seafood and soybean products. This attribute, combined with the search for new high-protein food sources for human consumption, accounts, in the main, for a new interest in krill. Another factor is the decline in the number of baleen whales. Estimates of baleen whale populations suggest that from the early 1900s to the present there has been about a 65 percent decrease in their numbers. Thus, whatever those whales used to consume might now be available to a different consumer species—humans.

One aspect of krill biology that makes them particularly attractive as the object of a new fishing industry is their habit of congregating in large, dense aggregations, sometimes referred to as swarms. These are occasionally sighted at the surface of the ocean as large, reddish patches. The largest recorded swarm measured about 2,000 feet in diameter, but most swarms average from 125 to 200 feet in diameter and are found anywhere in the upper 650 feet of water. In the austral summer of 1975–76, the West German trawler *Weser* averaged eight to twelve tons of krill per hour of net towing, with a maximum catch of thirty-five tons in eight minutes. The potential for a new industry is clear.

From a scientific and conservation point of view, however, things are not so clear. Of primary concern is that any new fishery not damage the antarctic ecosystem. With the ravages caused by unrestrained whaling still foremost in world consciousness, particular care is being taken to estimate what quantity of krill might be safely harvested. This reflects not only concern for safety in terms of the maintenance of the krill population itself but also safety in terms of the survival of the numerous species of animals that depend wholly or primarily on krill as their food source. The relative simplicity of the antarctic food chain makes it particularly vulnerable to disturbance and irreparable damage.

As the numbers of baleen whales decreased over the years, the potential krill surplus probably became a food source for growing populations of other animal species. Crabeater seals, which inhabit antarctic waters and feed primarily on krill, are known to be increasing in number. Consequently, there may be no actual surplus for human harvesting. Humans, instead,

Peter Johnson

Peter Johnson

might be competing for food directly with the seals or with penguins and other krill-eating animals. This competition would not necessarily entail damage to other species, but might reduce their numbers to previous levels.

All estimates of the quantities of krill that can be safely harvested and the potential impact of the harvesting on the antarctic ecosystem are, however, severely hampered by a lack of detailed information on overall krill biology. The need for information has become critical in the face of ongoing small-scale fishing tests in antarctic waters to determine the feasibility of full-scale krill-fishing operations there.

The original studies of the biology of krill were done during the British *Discovery* expeditions of the 1920s and 1930s. Nearly all the classical information on krill is contained in a voluminous 400-page work by J.W.S. Marr, who was part of those expeditions and investigated countless preserved samples of krill. Marr laid down the framework for all future research on this species. His conclusions, published in 1962, some thirty to forty years after the expeditions, remained essentially unchallenged until a system was developed in the mid-1970s for maintaining krill alive in a laboratory.

This development opened a new door in krill research by permitting captive animals to be studied over long periods of time. The system itself is quite simple, requiring only large tanks provided with flow-through seawater, maintained at temperatures below 39°F. Previous attempts to maintain krill alive in individual containers proved relatively unsuccessful for long-term maintenance. Part of the problem may have been lack of moving water to promote filter feeding and lack of temperature control.

That krill are found only in the Antarctic reflects their extreme sensitivity to what is for them elevated temperatures. The Antarctic Ocean is defined hydrographically by a moving boundary previously called the Antarctic Convergence but now known as the Polar Front. Of prime importance in krill distribution is the temperature discontinuity associated with it: south of this boundary temperatures remain below approximately 43°F, and north of it temperatures are considerably higher. Krill are superbly adapted to their frigid, watery environment, maintaining constant and often rapid

movement at temperatures in which investigators' hands are quickly paralyzed by the cold. The price for this adaptation is an inability to withstand any significant rise in their environmental temperature.

A sizable portion of the early work on krill was devoted to trying to determine how fast they grow and how long they live. Nowadays, these questions have become of utmost practical importance because life span is directly related to a population's ability to maintain itself in the face of harvesting. The longer it takes an animal to mature, the less resilient is the population.

Original estimates of krill life span were devised by examining formaldehyde-preserved samples and noting how many animals there were of any particular length. Using this method, most (but not all) of the animals were found to be approximately one of two sizes. An assumption was made that each peak size represented animals that were hatched within a given year, and the conclusion was drawn that the smaller group was a year old, and the larger group two years old. Consequently, the life span was estimated to be a bit over two years.

The assumption, of course, is that as animals get older, they get larger. It is true that as a crustacean grows, it must molt to replace its exoskeleton with a larger version since its rigidity will not accommodate an increase in body size. So, generally, a crustacean such as the lobster molts as it gets older and larger.

But krill have a peculiar biological quirk—for them, molting is not neces-

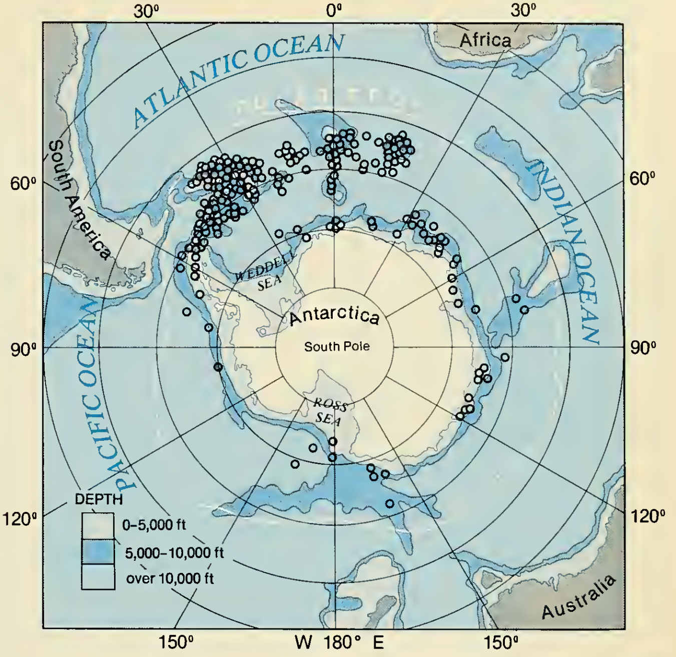
Peter Johnson

*Adélie penguins and crabeater seals are two animal species that feed primarily on krill. After a good meal, the seals' excrement is tinted pink.*

John Polkinghorn for Arroworld Wildlife Cinema

*This Polish stern trawler, although classified as a research vessel, is equipped to catch, process, and package krill. Poland is one of several countries actively engaged in fishing for krill in antarctic waters.*

Distribution of Antarctic Krill



Joe Lemonnier

sarily tied to growth. Instead, for unknown reasons, molting occurs at approximately constant intervals, whether or not the animal has increased in body size. Because of the patchy distribution of phytoplankton—the minute plant organisms that make up the major food source for krill—and extreme seasonal changes in light essential for the photosynthesis of these plants, krill cannot be assured of a steady food supply. Occasionally, specimens with empty digestive tracts are caught. Since live krill are almost transparent, it is easy to determine whether they have eaten. (A well-fed krill has a visibly green stomach, liver, and intestine; the color is faint or absent in nonfeeding animals.)

For survival, krill must swim throughout their lives; there is no rest, ever. Resting causes them to sink, taking them down to ocean depths where phytoplankton are absent because of inadequate light for photosynthesis. For krill to swim efficiently, good muscle attachments to the exoskeleton are a must. In times of inadequate food supply, krill can actually molt themselves down to a smaller size and maintain swimming efficiency. A population of krill kept in flow-through seawater tanks over the winter (at which time the phytoplankton content of the water is very low) showed a dramatic overall decrease in length. If their age had been ascertained solely on the basis of size, it would have been grossly underestimated.

Other attempts at establishing age have been based on the state of sexual maturity, determined both from the internal state of the gonads (the reproductive organs) and from secondary external sex characteristics. The adult female has a cuplike structure, known as the thelycum, on the ventral surface into which the male places two baseball-bat-shaped packets of sperm called spermatophores. Once placed on the female, the sperm packets extrude the sperm into a chamber of the thelycum, where they remain until the female is fully mature and releases her eggs. At that time, the female rocks the thelycum back and forth, forcing the sperm out of a slit that the eggs must pass. Fertilization is external. In the process of passing by the slit, the eggs are fertilized and released into the water. Depending on her size, a female may spawn 2,000 to 5,000 eggs over a period of a few hours, but because of natural mortality and predation, very few of these progeny live to become mature breeding adults.

Much effort has been put into observing the stages of development of the thelycum as a clue to the rate of maturation. The external sex characteristics of many crustaceans, such as crayfish, pill bugs, and sand fleas, are known to regress to less mature-appearing states after the reproductive season is over. Krill have the same rejuvenation strategy. Far from dying after spawning, as had previously been supposed, the female molts, thereby ridding herself of the sperm packets that externally identify her as having been mature. Within a short time, the ovary reorganizes to a seemingly juvenile state, with no mature eggs. And so, the maneuver is complete. With no ready clues to a previous spawn, no one could guess that many supposedly immature females found in samples had already spawned.

How often female krill go through this rejuvenation cycle is unknown. So far there is clear evidence for one such cycle; there may be more. Needless to say, this state of affairs does nothing to clarify how long they live, but together with evidence of their potential for shrinking, it puts Marr's estimate of a two-year life cycle into question. More likely, females live three or four years, perhaps more, and males probably have a similar life span.

While krill were spawning in the laboratory, the temptation to try to rear them from eggs was irresistible. With a diameter of 0.039 inch, krill eggs can conveniently be photographed during cell divisions, the first rudimentary appearance of limbs, and finally, the hatching of the first of twelve larval stages, the nauplius.

This initial oval larval form bears no resemblance to the krill's later adult form: it does not feed (its digestive

*The bones of a baleen whale litter a beach on King George Island, off Palmer Peninsula in Antarctica. These whales, known to migrate to the Antarctic to consume krill, became the easy prey of whalers. Overharvesting is estimated to have reduced their population by about 65 percent in this century alone.*

Pete hnson

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tract is not yet complete and won't be until it reaches the fourth larval stage), its swimming capacity is quite limited, and it has only three pairs of appendages compared with an adult's nineteen pairs. The first two pairs eventually alter in structure and function and become the antennae and antennules of the adult, and the third pair gradually transforms into one of the adult mouthparts, the mandibles. In terms of evolution, crustacean mouthparts are modifications of legs. These transformations can be observed through the many larval stages of krill development.

Laboratory rearing was successful only to the third stage, the metanauplius, after which the animals succumbed to an invasion of bacteria, a common problem in rearing planktonic species in captivity. Previous investigators, working with preserved samples caught at various times of the year, have inferred that a larva takes about nine months to pass through all twelve stages and become a miniature krill, at that time only about one-quarter to one-half inch in length. Reliable information on the krill's first year of life still awaits the laboratory rearing of larvae through all stages.

Often, samples of krill fished from the ocean are predominantly of a single age—larvae, adolescents, or adults. With about 24 million square miles of Antarctic Ocean to inhabit, how do aggregations occur at all, let alone age-specific ones? Clearly, this propensity for distribution in dense patches is what makes krill a good food source for animals and potentially a good fishery resource. If krill of all ages were evenly distributed throughout the vast expanse of ocean, feeding on them would be inefficient and fishing for them impractical. Since swarms do not appear to be uniform mixtures of all ages, perhaps an understanding of how krill form and maintain swarms, and how the swarms themselves behave, might allow for selective fishing; for instance, swarms of mature animals could be avoided during peak reproductive periods.

True swarms, which can be at varying depths, are similar to fish schools in that the animals are oriented parallel to one another and the swarm appears to move as one large, integrated organism. Some krill aggregations are not so highly organized but apparently remain together. This togetherness is maintained both horizontally and vertically, as the krill tend to move closer to the surface at night and to greater depths during the day, apparently in response to changing light levels. How do they accomplish the feat of remaining together?

One likely mechanism is light signals among the krill themselves. At night, the ocean is sometimes filled with tiny, blue green lights that scintillate brightly like a fairyland creation. Many organisms contribute to this magnificent luminescent display; foremost among them are the krill. Each animal is equipped with ten round, cuplike light-producing organs called photophores, which the animal can flash on and off or keep brightly lit for some minutes.

The chemical production of light by organisms ranging from molds to fish has fascinated people, probably for millenniums, but its function in many species is still poorly understood. A clue to its function in krill may be the observation that krill are attracted to dim light. In laboratory experiments, their attraction to light of different wavelengths (colors to us) was tested by shining a narrow beam of light into a large tank and then taking flash photographs of the krill distribution. The animals were found to aggregate in this light even though it was too dim for the human observer to see. Perhaps by producing light of their own, krill are attracted to each other, forming and maintaining aggregations.

Their large and prominent black eyes are well adapted to life in relatively dim light—a study of their optical properties has shown their eyes to be sixteen times more sensitive to light than are ours. In fact, when taking the laboratory photographs, it became evident that krill were still responding by aggregation to light intensities too faint for us to see.

In this faintly lit environment one also wonders what means mature males and females use to recognize each other for mating. The answer may be pheromones (chemical secretions) or some visual cue, for example, sex-specific bioluminescent flash patterns. Mating has never been observed, however, so theories about recognition are still purely conjectural.

On one occasion, the peculiar behavior of two krill in the tanks suggested that mating was occurring. The two animals were hastily removed and examined, and much to our surprise, the head of one was missing. There hadn't been any mating; it was cannibalism that was going on. The color of the predator krill's gut confirmed that it was making a meal of its peer; instead of the usual phytoplankton green, the intestine contained black eye material and the liver was reddish from the carotenoid pigments of the prey animal's chromatophores—pigment-containing cells.

Casual observation of the tanks subsequently showed a low but steady incidence of cannibalism. The question that arises is, was this a natural, normal occurrence or an artifact caused by captivity? We found that even in natural populations, some cannibalism occurs and not necessarily in response to low food levels. Among many well-fed krill caught at sea, we would occasionally find one with the telltale red gut.

In fact, the krill appears to be an opportunistic omnivore, rather than an exclusive herbivore, as previously thought. Krill have been found eating pteropods (small snails with a foot modified into a winglike structure with which they "fly" through the water, giving them the name "sea butterfly"), copepods, annelids, detritus, and even chips of paint that have inadvertently entered the holding tanks on board ship. The constant filtering movements the krill make with their finely bristled thoracic legs are probably not as selective as once thought. This makes good survival sense since an omnivorous feeding habit is more flexible than a selective one. To what degree this flexibility affects the growth (or shrinking) rate of krill in low phytoplankton conditions belongs again to the long list of questions on their biology.

As these many studies on krill biology are proceeding, so are the commercial fishing tests and product development both in the United States and abroad. The Japanese and Russians were the pioneers in krill processing as well as harvesting. In both Japan and the USSR, krill products have been available for human consumption for some years as cooked frozen whole krill, pastes, and spreads. Chile has developed a process for producing "krill sticks" similar to the familiar fish sticks in our supermarkets. Krill has reached the U.S. marketplace primarily as food for pet fish. Krill are also used, but not yet in the United States, as a protein filler in any of a number of products—sausages, sauces, soups, meatballs, pies, and stews. Because it has only a faint taste, krill meat, like soybean meal, is an excellent high-protein extender for a wide variety of food products. Beyond its potential as a human food source, krill meat may some day find uses in domestic animal feed and in aquaculture where the red pigments of the krill impart a commercially desirable pink color to the flesh of fish fed on them.

The development of new krill products does not stop with the meat, however. The chitin, or horny portion, of the exoskeleton can be purified into a substance called chitosan that has potential application in such diverse fields as water purification, chromatography, pharmaceuticals, food stabilizers, paper manufacturing, and adhesives. In fact, the adhesives used for gluing together the wooden airplanes of World War I were derivatives of chitin.

The raw materials for these products are derived from a present annual harvesting rate on the order of 80,000 to 90,000 metric tons of krill by the USSR, Japan, Poland, West Germany (FRG), Chile, Norway, Korea (REP), Argentina, and Spain. Such catch rates are relatively small when compared with estimates of standing stocks of krill ranging from 125 million to 6 billion metric tons.

These stock estimates reveal two important considerations: first, that the stock is indeed large and commercially attractive, and second, that there is as yet no reliable method of assessing its actual magnitude. Stock assessments made thus far have relied on scant data. Some estimates have been based on extrapolations of how large a krill population the phytoplankton of the Antarctic Ocean could support; others have relied on localized sampling of krill. Given the patchy distribution of both phytoplankton and krill, neither method is very reliable. The possibility of using satellite photographs of the Antarctic Ocean for the detection of large swarms of krill offers more promise but is still in its early stages of development.

The combination of accurate stock estimates and answers to basic biological questions concerning krill holds out the best promise of a harmonious combination of resource utilization and conservation. And the international recognition of the need for additional regulations reflects an awareness of the necessity for judicious management of Antarctica's unique resources and the preservation of its remarkable ecosystem for present and future human generations. ☐

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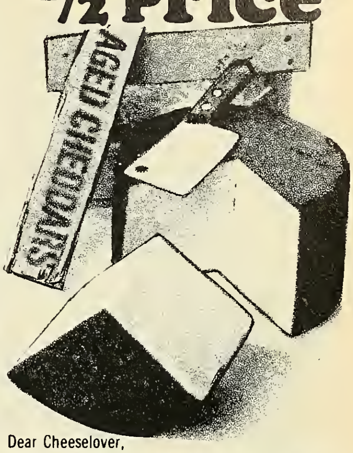

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# At the American Museum

*Roaches who ride the city's buses now have a foe in the Museum*

Dear Sir,

I'm hoping this is not another exercise in futility. Letters of complaint are so easy to ignore, so I rarely, if ever, write them. It seems only the danger of public exposure produces any effect.

Most of the time, despite momentary flashes of anger, one can shrug off the indifference, hostility, and even outrageous rudeness unleashed by bus operators on the unfortunate riders of the New York City bus system.

But Roaches!!! And from the many sizes, second generations of them!! How dare you inflict this on those who support your system, pay your salaries, and put their trust in you. Roaches—I will not sit still for them. This horde of roaches was on bus number 8553, October 4, 1979, at 2:50 P.M.

This obviously bespeaks gross negligence as well as total indifference. Littered buses, soiled windows—bad enough. But vermin? I can't imagine the heyday the media could have with such a news item, and unless something is done, and fast, I shall do everything in my power to see that it is publicized.

(Signed) A Disgusted Rider

Cockroaches have been riding the city's buses for over fifty years. Generally, they have kept a low profile and stayed out of trouble. In the last few years, however, the dramatic increase in the number of bus-riding roaches has driven some of their fellow commuters to the point where they have felt compelled to write to the New York City Transit Authority (witness the above letter). After trying one ineffectual remedy after another, the Transit Authority finally turned to the American Museum of Natural History last year for help.

Joseph DeVito, director of safety for the Transit Authority, explained the peculiar and paradoxical nature of the problem: "A few years ago, the T.A. embarked on a comprehensive program of bus washing. Believe it or not, the more we washed the buses, the more complaints we got about the roaches." In response to the rising tide of letters the Transit Authority stepped

*Roaches often take free rides on unsuspecting humans.* Paul Sher up its insect bomb and fumigation program. But the itinerant roaches, like roaches everywhere, held fast to their domain. Other remedies were attempted: one ingenious engineer even rigged up a grid of live wires in a favorite roach hangout on one bus, but after several electrocutions the bugs learned to avoid the trap.

It was at this point that Herb Crannan, a Transit Authority executive, suggested that an entomologist might be able to help. Explains DeVito, "We hoped that by studying their behavior, perhaps there would be a way—something like the Pied Piper of Hamelin—to get the insects to march right off."

Betty Faber, a research associate in the Museum's Department of Animal Behavior and an authority on roach behavior, offered her expertise free of charge. The T.A. gave her a transit pass, and she began riding the buses and visiting the terminals, jotting down the behavior of the itinerant roach in her field notebook.

Faber is used to following the vagaries of roaches; she keeps her own colony of wild roaches in the Museum's rooftop greenhouse, where they share quarters with electric eels, black-jawed fish, and various aquatic and terrestrial plants. Faber provides her roaches with protection from insecticides, but the roaches have to shift for themselves when it comes to food and water. Each roach, in turn, assists her in her research by wearing a numbered tape strip on its back. At night, bathed in the glow from an infrared light invisible to roaches, Faber can be found stalking her busy wards while they go about their business or watching them on closed circuit television from cameras set up in strategic locations.

The cockroach, Faber explained, is among the earth's most venerable inhabitants. It has survived because it has been able to cope with changing environments. Its eclectic eating habits may have helped: the roach has feasted on everything from brontosaurus flesh in reeking Cretaceous swamps to stray

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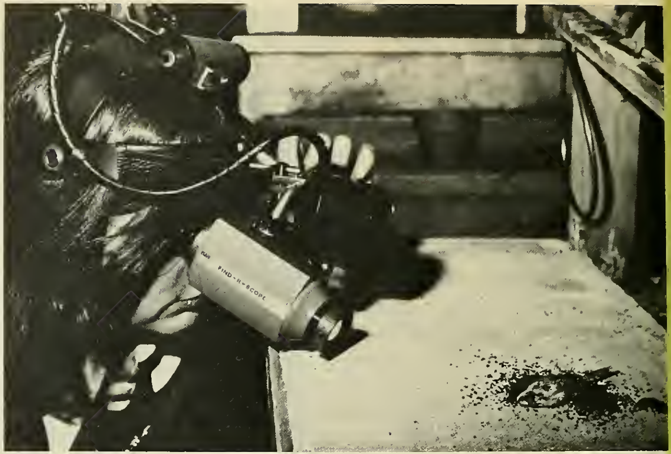
*Faber follows the nocturnal habits of her roaches with this special magnifying camera that can "see" in invisible infrared light.*



Paul She

crumbs in spotless Park Avenue kitchens. It even eats the inner organs of televisions sets and refrigerators.

The roach's adaptation to city life is quite remarkable. Despite vigorous efforts to eliminate them, roaches can be found at the best addresses and in some of the finest restaurants in New York. (Faber cited one exclusive restaurant that contacted her about a seemingly unsolvable roach problem.) And, of course, they are sometimes seen riding the city's buses.

The bus-riding bug, Faber says, is usually the German cockroach. Long a victim of wanderlust, this peripatetic roach immigrated to New York City at least a century ago and established itself as the dominant species. (The larger American roach is still around, however.) Like most cockroaches, the German roach is attracted to water. Faber suggested that the comprehensive bus-washing program may have made the city bus a wetter, and thus more appealing, environment. People eating on the buses provide the roaches with food (she noted that eating on buses is more common now than five years ago), while the engine and heating system provide them with warmth.

But the real question is how roaches get on the buses in the first place. "A roach," says Faber, "could conceivably climb on a bus while it is in the terminal. But the terminals, contrary to popular opinion, are very clean and most are unheated. Anyway, it's like climbing Mount Everest for a roach to get on a bus by itself." She also discounted the theory that roaches breed on the buses.

"I think it's safe to say that the roaches get on with the passengers and then get off the passengers while they are on the bus. These German roaches will hang on tight when disturbed or upset. A perfectly clean person could be carrying a roach this way."

When Faber files a report with the Transit Authority, she will recommend simply that the buses be kept clean and dry, especially the back-seat area, where roaches and rubbish tend to accumulate. This approach may prevent roaches from staying too long on any one bus, but it won't prevent them from getting on with people. That problem, many agree, is unsolvable. "There isn't that much you can do about roaches, after a point," says Faber, "except to learn to live with them. Roaches are a lesson in humility for all of us humans."

Or, as archy the cockroach, created by Don Marquis, put it:

i do not see why men
should be so proud
insects have the more
ancient lineage
according to the scientists
insects were insects
when man was only
a burbling whatisit

*archy and mehitabel*
*certain maxims of archy*

*Douglas J. Preston*

**Guarding the Source**

An important concern of anthropologists has been how to preserve source material of rapidly changing or dying cultures. L.P. Greenhill, founder of the U.S. Archives of Encyclopaedia Cinematographica, will present *Film as a Means of Safeguarding Source Material in Ethnology* on Sunday, March 9, at 2:00 P.M. in the Auditorium. During his discussion, he will show a number of German ethnographic films that are meant to be an objective record of human behavior for later anthropologists to study. Most of the films are presently stored at the Institute of Scientific Film in Göttingen, West Germany. There is no admission charge.

**Discovery Tours**

The Museum is offering a tour of Papua New Guinea and Australia this September. Museum ornithologist Mary LeCroy, a specialist on birds of paradise, and Australian anthropologist Keith Buxton will lead tour participants to the remote areas of the South Pacific in search of wildlife. Tour members will also observe the markets, villages, and ceremonies of the indigenous peoples of the area. The Museum is sponsoring other trips to the British Isles, Alaska, and China in 1980. For further information, write to Discovery Tours at the Museum.

**Microbes, Millipedes, and Mountain Lions**

The spring series of *Workshops for Young People* will begin in April. The weekend workshops provide an opportunity for children in grades 4 through 7 to learn about such topics as nature photography, the microscope, mammals of North America, human origins, and insects. The courses run from two to six weeks and cost between $10 and $20. Write to the Museum for more information.

**The Rising Sun**

Japan is the featured country in the People Center during March. On four weekends, the many facets of traditional and modern Japanese culture and society will be presented through lectures, films, demonstrations, music, and workshops. The programs, which will run from 1:00 to 4:30 P.M. on Saturdays and Sundays, are free and open to all Museum visitors.

**The Biggest of Them All**

On Sunday, March 16, at 2:00 P.M. in the Auditorium, Ismael Calderon, of the Department of Education, will use sound recordings and films to illustrate the environment, behavior, and ecology of whales. The show, *Whales*, is open only to members of the Museum and their guests.

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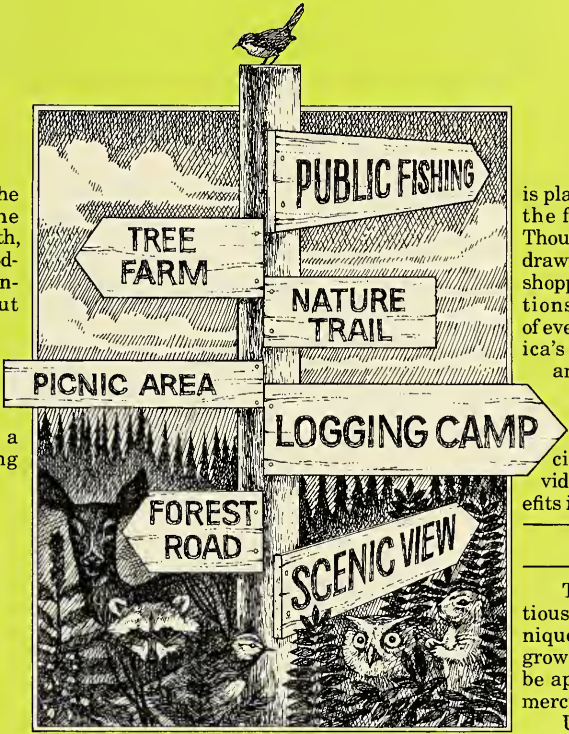

## Sharing the benefits

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But demands on the commercial forest are growing at an alarming rate. An expanding population is placing new pressures on the forest for recreation. Thousands of acres are withdrawn every year for homes, shopping centers and additions to Wilderness. And of even more concern, America's consumption of wood and paper products is expected to double in the next 50 years.

Can the commercial forest keep on providing these multiple benefits indefinitely?

## The big if

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So there is a long road ahead if America is to continue to receive multiple benefits from the forest.

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by Stephen P. Maran

# Two Satellites in Search of X-rays

*Information from observatories orbiting in space bears on the question of whether the universe is open or closed*

The "diffuse background" of X-rays that bombard the earth equally from all directions in space has been studied with two recent NASA satellites, HEAO-1 and HEAO-2. The results indicate that the universe may be filled with superhot gas or with an unexpectedly large number of quasars or possibly with both.

The diffuse background was discovered in 1962. Ever since, astronomers have differed as to whether it is truly a diffused (that is, widely distributed rather than localized) emission or the result of innumerable individual objects, each of which produces X-rays. The problem reminds me of the ancient concept of the Milky Way as a luminous stream in the sky. Galileo's telescope later revealed that the stream was simply the summation of millions of faint stars that cannot be individually distinguished by the human eye. Is that the case as well with the diffuse background of X-rays? Are our first X-ray instruments just too crude to resolve a myriad of cosmic X-ray sources?

The diffuse background actually differs depending on the X-ray energy at which it is observed. Shorter-wavelength X-rays have higher energies and are called "hard" X-rays; "soft" X-rays are those with lower energy and longer wavelength. Measurements made since 1962 have shown that the background of the shorter-wavelength hard X-rays (those with wavelengths less than about 1/1000 of visible light) is isotropic, meaning equally bright in all directions as seen from the earth. This indicates that the radiation is not produced by stars (or by hot gas, for that matter) in our own Milky Way galaxy. If it were, it would be brighter in some directions than others. The observation of isotropy thus indicates that whatever produces the diffuse background of hard X-rays must be far outside the Milky Way, in remote extragalactic space.

Measurements of the background of the longer-wavelength soft X-rays, on the other hand, *do* show pronounced deviations from isotropy and indicate that the background is largely produced within our galaxy. That makes it difficult to observe the diffuse emission of soft X-rays from beyond our galaxy, although observations of bright "point" sources, such as distant quasars, are possible. This difficulty is germane to the story that will unfold below, and is analogous to the effect of a full moon in the sky, whose scattered glow in the atmosphere makes it hard for a viewer to see the Milky Way, although individual bright stars can still be readily perceived.

Each of the HEAO (High Energy Astronomy Observatory) satellites that observed the diffuse background carried several instruments to study X-rays from the cosmos. The payload of HEAO-1 included an instrument known as A2 that was designed to study the overall structure of the universe as it might be revealed by X-rays from distant space. HEAO-2, dubbed *Einstein* to commemorate the great physicist, carried a large telescope capable of focusing an X-ray image onto any of four onboard instruments, as chosen by command from the ground. With the aid of this telescope,

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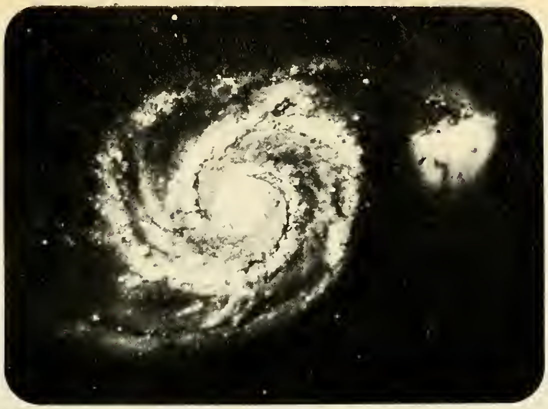

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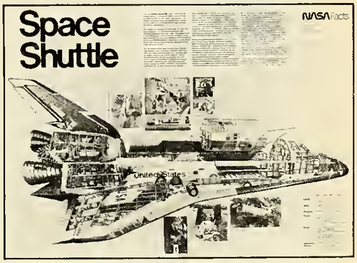

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the HEAO-2 instruments were employed to make the most sensitive observations yet possible of individual X-ray sources beyond the solar system, such as distant stars and galaxies.

HEAO-1 was launched in August 1977 and shortly thereafter the A2 experiment began mapping and measuring the diffuse background. A most important task was to measure the intensity of the background in hard X-rays as a function of the wavelength of the rays. The dependence of intensity on wavelength, which is demonstrated in the X-ray spectrum, gives clues to the physical process that produces observed X-rays. Further, if it should be true that the diffuse background arises in numerous individual sources, then the spectrum of the background should resemble the summation of the dimmer spectra of many such sources.

Once HEAO-2 was launched in 1978, it became possible to accurately measure the X-ray spectra of nearby representative members of each class of extragalactic X-ray source: galaxies, peculiar galaxies (known respectively as Seyfert galaxies, N-galaxies, and BL Lacertae objects), clusters of galaxies, and quasars. Then, numerical trials with computers might determine the recipe by which many very distant members of these classes of objects can blend together to produce the diffuse background. The question was, Do we need a quart of galaxy clusters, a cup of quasars, and just a pinch of Seyfert galaxies to make the observed blend or must the spectrum of the diffuse background be produced mainly by vast numbers of just one kind of source?

In March 1978, Elihu Boldt, a physicist at the Goddard Space Flight Center who is principal investigator for hard X-ray studies by the A2 aboard the HEAO-1 satellite, gave a progress report on the measurements of that instrument. At the annual meeting of the American Association for the Advancement of Science in Washington, D.C., he noted that although less than 5 percent of the data eventually to be collected during HEAO-1's operating lifetime had been received at that time, a basic finding had been made. He told the assembled scientists that the X-ray spectrum of the diffuse background "suggests that it is a thermal emission from a hot plasma at an effective temperature of a half-billion degrees."

Plasma, as the term is used in astronomy, means electrified gas in which electrons have been stripped away from atoms. One interpretation of the HEAO-1 measurements is that Boldt's suggested hot gas may produce the background of hard X-rays that fills distant space in a uniform manner. In that case, given the observed intensity of the X-rays, and the gas temperature as revealed by the shape of the X-ray spectrum, one can calculate the density of the plasma. This computed number turned out to be large enough, Boldt found, that the mass of hot plasma present in space "is about half that required for closure of the universe."

If this observation is correct—and Boldt himself now questions it—then these HEAO-1 observations have a direct bearing on the fundamental cosmological question, Is the universe open or closed? As most people know, the universe was apparently born in an enormous explosion, the Big Bang, about ten to twenty billion years ago and is still expanding. All the clusters of galaxies in space are flying apart from each other as a consequence of the Big Bang. As they fly apart, they are gradually slowed down by the retarding force of gravity. If the density of matter in the universe is sufficiently large, then some day (many billions of years from now), the galaxies will slow down to zero expansion speed and will then begin to fall back together, eventually all to meet in some cosmic catastrophe of the remote future. If this is the case, then the universe is "closed." If, however, the density of the universe is lower than a certain critical value, then the galaxies (although gradually slowing down) will never actually reach zero speed. Like rockets launched from the earth at speeds above the earth's escape velocity, they will fly apart forever. That situation describes an "open" universe.

The 1979 index for *Natural History* may be obtained by writing to:

Index
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The problem cosmologists have faced in studying the question of an open versus closed universe is that, although there are some indications that the universe might be closed, there has not seemed to be anything like the

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amount of matter present in space to insure that possibility. Photographs from Palomar seem to show a universe filled with glowing clusters of galaxies, but, in fact, the galaxies are so far apart that the universe consists mostly of dark, empty space, or so it has seemed. Hence the observed density, computed from the occurrence of galaxy clusters, was only a few percent of the critical value required for a closed universe.

If Boldt's 1978 analysis is accurate, however, we have evidence that the density of the universe is at least a substantial fraction of the critical density required for closure. (Analysis of further HEAO-1 data, reported in January 1980 by Boldt and others at the Goddard Center, reduced the early 50 percent estimate to 36 percent, which is still a substantial number.) Whether the universe is open or closed, the A2 experiment (if its measurements have been correctly interpreted) detected and mapped the majority of matter in the universe. That matter is not mainly in the form of visible objects such as stars and galaxies, as astronomers have generally assumed. Instead, it consists mostly of the superhot plasma that apparently fills space between the clusters of galaxies. The plasma is so thin and hot that it shines only in X-rays, not in visible light. However, data from the *Einstein* satellite indicate that the superhot plasma may not exist.

*Einstein* was launched in November 1978. While its measurements and observations are revolutionizing many areas of astronomy, three of its instruments have had special application to an explanation of the source of the diffuse background. Those three instruments, called the IPC (imaging proportional counter), HRI (high resolution imager), and the SSS (solid state spectrometer), have specifically addressed the question of finding the recipe to blend many single X-ray sources to form one diffuse background.

Several aspects are involved in determining whether a "perfect blendship" actually exists. The respective numbers and brightnesses of very distant X-ray sources must be determined and the shapes of the X-ray spectra of each type of source must be learned.

The IPC and HRI instruments were used to detect X-ray emitting quasars and galaxies at far greater distances than previously possible. These instruments made long-exposure X-ray photos of fields of view that were selected in order to avoid the Milky Way and known, relatively nearby galaxies

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and other objects. The location of each bright spot, or "point source" of X-rays, revealed by the photos was measured and furnished to optical astronomers, who used the locations to determine the identity and distance of the objects. Objects found in this way included quasars, galaxies, and foreground stars. In addition, thirty-five already known quasars were photographed with the two instruments, to determine the strength of their X-ray emissions. As a result of this work, a team of investigators at the Center for Astrophysics in Cambridge, Massachusetts, concluded that "a large fraction of the diffuse background is due to previously unresolved discrete sources."

Particular support for this point of view came from the IPC and HRI quasar studies, which were led by astronomer Harvey Tananbaum of the Cambridge group. The Tananbaum study found evidence, as expected, that quasars are at the distances implied by the cosmological interpretation of their red shifts, which states that the shifts are due to the expansion of the universe (see "Quasars Confirmed," *Natural History*, February 1980). Further, by combining the average X-ray emission of a quasar of given visible-light brightness, as determined by *Einstein*, with the relative numbers of quasars of different visible-light brightnesses, as revealed in ordinary telescopic studies, Tananbaum found indications that quasars alone may be present in sufficient amounts in distant space to account entirely for the diffuse background of hard X-rays. In other words, the background may be due to a superposition of discrete sources.

In the meantime, the Goddard astronomers have conducted new studies with the SSS instrument on the *Einstein* satellite. The IPC and HRI instruments told us that there apparently were enough quasars and other individual objects of sufficient brightness to create the diffuse background, but they did not indicate whether these sources have spectra of the right shapes to blend together. In fact, IPC and HRI are soft X-ray instruments and thus measure quasars and galaxies exactly at the wavelengths where, as already explained, the diffuse background from distant space is *not* observed. To believe Tananbaum's conclusions, you have to extrapolate from numbers and brightnesses of quasars and other sources observed in soft X-rays to numbers and brightnesses of the same

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objects as they would appear in hard X-rays.

In hard X-rays, however, the technology does not exist to observe so many and such distant quasars as was possible with the soft X-ray instruments. Thus the SSS-instrument studies were addressed to measurements of the X-ray spectra of nearby bright quasars and galaxies. These studies found that the spectra do not have the right shapes. You cannot add together many quasars and galaxies with spectra having the observed shapes and simulate the observed spectrum of the diffuse background of hard X-rays. There probably is a diffuse background of extragalactic origin in *soft* X-rays that arises from quasars, but it is as yet unobserved from the earth because of the interfering flow of soft X-rays from our own Milky Way.

My own conclusion is that the concept of a diffuse background of hard X-rays as produced by individual objects at great distances is not yet proved. Yet the HEAO-1 result, that the background arises from superhot plasma that fills the universe, is also on somewhat shaky ground, and its original proponents no longer believe it.

The most likely resolution of the dilemma comes from the concept of evolution in the universe. The objects whose spectra were measured with the SSS are relatively nearby. That means that the X-rays that have been received and measured from those objects were produced during a relatively recent epoch. On the other hand, the innumerable discrete sources that may make up the diffuse background (if such is the case) must be vastly farther away. That means that the X-rays we are receiving from them were produced during a much earlier epoch in the history of the universe. Perhaps the nature of the objects present in space has changed substantially since then. In that case, the SSS studies of nearby quasars and galaxies tell us only about recent times and give little or no information about the spectra of galaxies and quasars long, long ago. In the early stages of the universe, objects may have been present that had spectra of the right shape to produce the observed diffuse background. If so, then the perfect blendship existed; if not, the universe may be closed and is mostly just a gas.

*Stephen P. Maran is senior staff scientist in the laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Maryland.*

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# Celestial Events

### by Thomas D. Nicholson

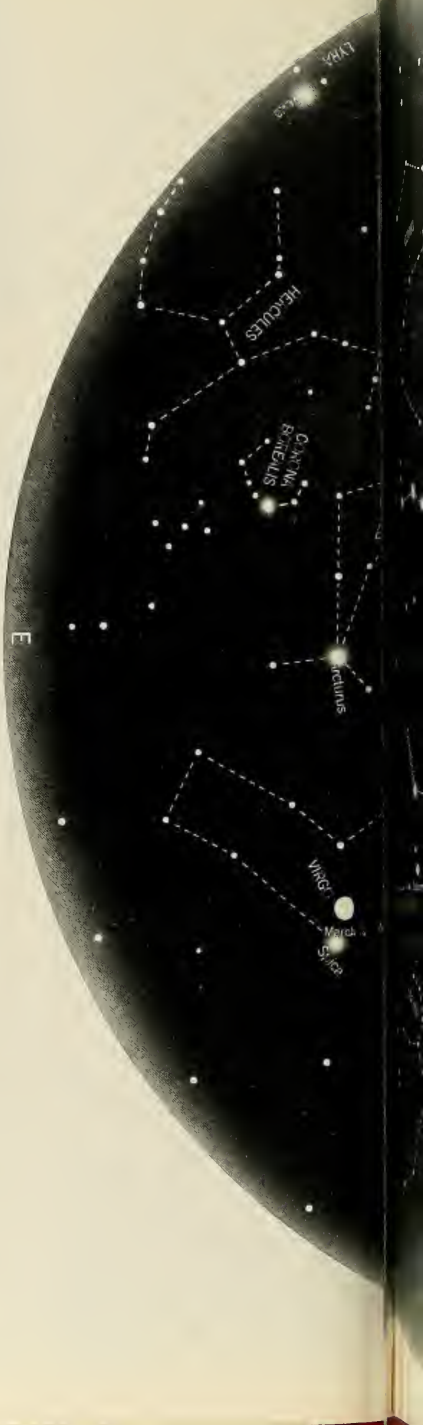
**Sun and Moon** The sun is in the constellation Aquarius until the 12th of March, then moves into Pisces, where it arrives at the vernal equinox on the 20th. After mid-April it moves into Aries. The effective equinox (when days and nights are each 12 hours) occurs on March 17, but the sun's center arrives exactly on the equatorial plane on March 20.

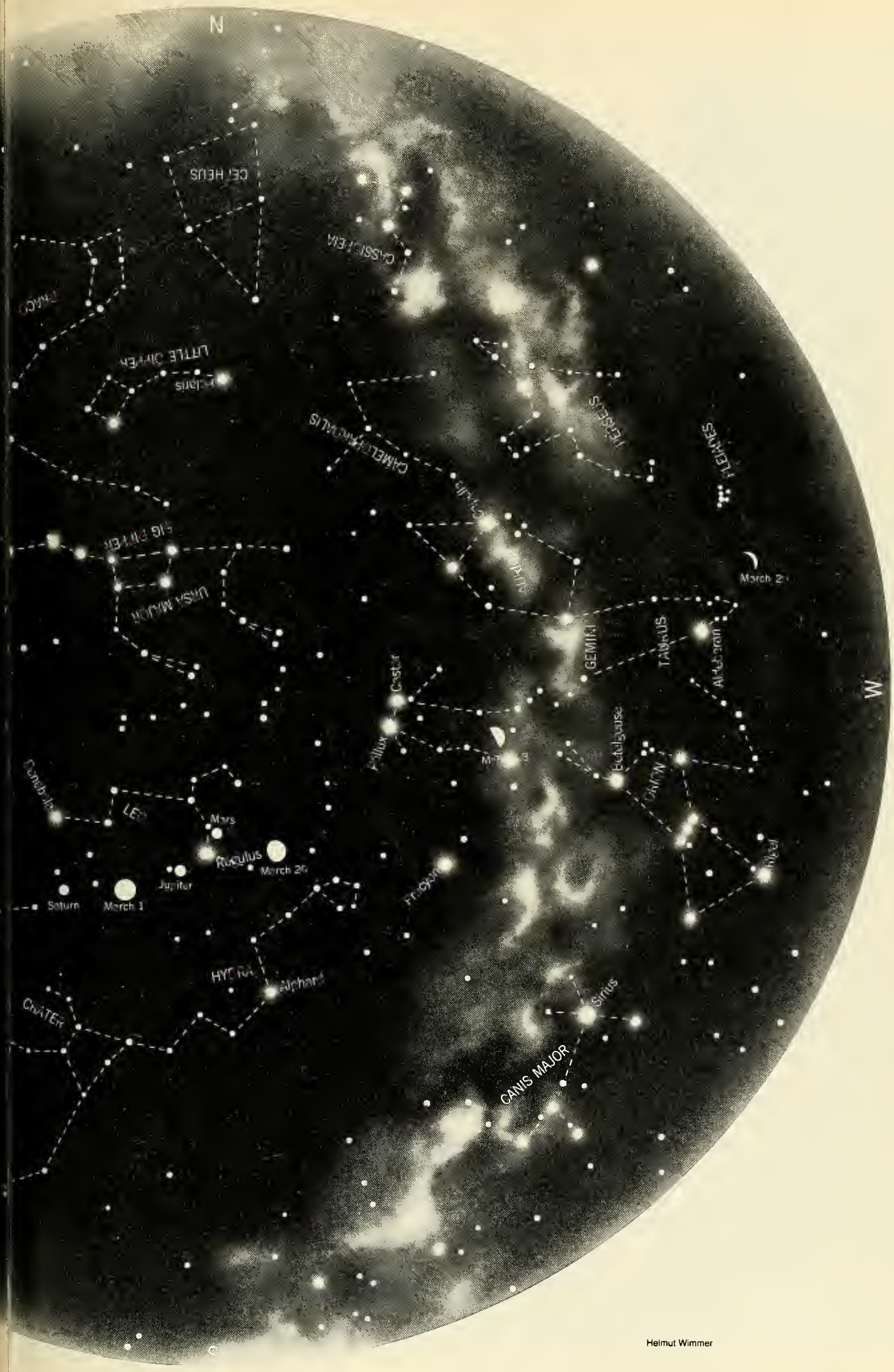
Both March and April begin and end with full moons. Phases in March are: full on the 1st, last-quarter on the 9th, new on the 16th, first-quarter on the 23rd, and full again on the 31st. Phases in April are: last-quarter on the 8th, new on the 14th, first-quarter on the 21st, and full on the 30th. A penumbral lunar eclipse (barely dimming the moon's brightness) occurs on March 1. New moon for both months occurs near perigee (when the moon is nearest the earth), two hours before perigee on March 16 and twenty-one hours after on April 14. The effect will strengthen the spring tide on both dates. Apogee (when the moon is farthest from the earth) occurs on March 3 and 30, and April 26.

**Stars and Planets** Get acquainted with the evening planets early in March so you can follow their antics over the next several months. Venus should be first on your list. Now going through a very favorable evening elongation, it pops up in early twilight high in the east, so brilliant that you might mistake it for a landing aircraft (or a "flying saucer"?). It remains in the sky nearly four hours after sundown. Next are Mars, Jupiter, and Saturn, near the bright star Regulus in Leo. Look for them in the east (*opposite* Venus) when it grows dark. Once you find them, you can track them all night long, for they don't set until dawn. Jupiter is easy to recognize, eclipsed in brightness only by the moon and Venus. Mars (ruddy in color and next in brightness) and Regulus are to Jupiter's west (right), while Saturn (about the brightness of Regulus) is to the left and more distant. Once you sort out these four objects, you will enjoy their changes over the next several months. Mars dims rapidly and passes Regulus and Jupiter *twice* each. How? Just watch and see! And the moon will be a special visitor to this group of objects on February 29–March 2, March 27–29, and April 24–25.

February 29–March 1: The moon passes Regulus, Mars, and Jupiter.
March 1: Beginning with Jupiter today, the moon occults Jupiter and Saturn three times each, Regulus and Aldebaran twice each, and Mercury once during March and April, but only two occultations (Aldebaran on March 21 and April 17) occur over North America and neither will be easily seen.
March 2: Mars passes Jupiter at 2:00 P.M., EST.
March 6: Mercury, in inferior conjunction, becomes a morning star.
March 13: Saturn, at opposition, becomes an evening star.
March 17: Mars passes Regulus at 4:00 P.M., EST.
March 19: The moon is near Venus tonight and Aldebaran the 21st.
March 20: Spring begins at 6:10 P.M., EST.
March 27: The moon passes Mars, Regulus, and Jupiter tonight, Saturn on the 29th.
April 2: Mercury, at greatest westerly elongation, is not well placed as a morning star.
April 5: Venus, at greatest easterly elongation, is *very* well placed as an evening star.
April 7: Mars is stationary and resumes direct (easterly) movement.
April 14: Venus passes Aldebaran tonight.

★ Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:20 P.M. on March 1; 10:25 P.M. on March 15; 9:20 P.M. on March 31; and 8:20 P.M. on April 15; but it can also be used for an hour before and after those times.

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Mars
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March 26
Jupiter
Saturn
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Procyon
HYDRA
Alphard
CRATER
Sirius
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Helmut Wimmer

# Reproduction by Duplication

*For many plants, cloning is a way of life*

**by Robert E. Cook**

> Cloning is the most dismaying of prospects, mandating as it does the elimination of sex with only metaphoric elimination of death as compensation. It is almost no comfort to know that one's cloned, identical surrogate lives on, especially when the living will very probably involve edging one's real, now aging self off to the side, sooner or later.
>
> Lewis Thomas
> *New England Journal of Medicine,*
> December 12, 1974

People get very upset at the prospect of cloning a human being. We have been quite content to coexist with identical twins since Castor and Pollux, perhaps because such twins are hardly ever identical in the essentials of life. But the possibility, although remote, of taking a cell from one human being, and with it creating such a twin, has generated public anxiety, numerous ethical questions, much rhetoric, and on occasion, a touch of eloquence.

Plants, on the other hand, are quite casual about cloning, with hardly an ethical glance at the prospect of a world populated by multiple copies of themselves. Many plant species, perhaps most, have evolved the ability to reproduce asexually by one means or another, whether it be the ground-level runners of strawberries or the delicate, asexual seeds of dandelion, hawkweeds, and blackberries. Asexual reproduction in plants is like growing itself; it is done with all the ease and facility of producing a new branch.

In fact, many botanists prefer to call this process clonal growth rather than asexual reproduction. But their preference arises from focusing on the process. The result—a genetically identical daughter plant that eventually becomes physically separate and physiologically independent from the mother—suggests that reproduction of a sort is indeed taking place.

Take the starflower, for example. This modest little forest herb emerges early in spring with five to eight whorled leaves at the end of a delicate stem and, sometimes, a tiny, white, seven-petaled flower rising above them. Throughout the summer the plant produces no new leaves; the real action is occurring below ground.

In late June, one or more underground stems grow from the base of the shoot and snake their way through the tangled mass of roots, rocks, and litter lying just below the surface of the forest floor. In July, as the days begin to grow shorter, the entire metabolism of the individual changes. Nutrients are shunted from the mother plant to the thickening tips of the underground rhizomes, where they are stockpiled as proteins and starch to form a swollen tuber complete with quiescent bud. In August the whorl at the summit begins to yellow and senesce, and the plant transports the nutrients in the foliage to parts below ground.

By October the mother plant has fully disintegrated, as have the underground connections to her newly formed and genetically identical daughters, which may lie up to three feet apart. The daughters in turn remain dormant through winter and commence growth with the warming of the soil in spring. They emerge through the litter in May, provisioned by the tuber until newly formed leaves begin photosynthesis. What was once a single plant has now become two, and sometimes three, physiologically independent individuals.

Although the starflower displays a rather modest rate of duplication appropriate to its shady understory habitat, there are some very impressive clones that carry on rapid self-replication for ages. Grasses, for instance, can acquire new ground through tillering, a process in which a bud at the base of a blade begins to grow sideways, soon rooting to form a new shoot beside the parent rosette of leaves, and tillering in its turn. With time the original physiological connection between parent and offspring becomes dormant and decays. Such clumps of grass may vary in size and density depending on how much lateral growth occurs before the growing bud roots and sends up a shoot.

Swedish botanist Daniel J. Harberd became curious about how large such clones might grow in old pastures and grasslands. He knew that plants of identical genetic constitution are self-incompatible, that is, individuals within the same clone cannot form successful seed when the male pollen of one lands on the female pistil of another. Such a system, somewhat the reverse of graft incompatibility in man, has evolved in many species to insure the exchange of pollen between genetically different individuals.

With large-scale sampling and crossing experiments Harberd identified different plants that had arisen from a single seed through sequential tillering. To his surprise, he found in one pasture a clone of the common red fescue, *Festuca rubra*, which stretched more than 240 yards. By calculating the rate of tillering, Harberd estimated the plant was more than a thousand years old.

In a second study Harberd found an entire pasture of creeping soft grass, *Holcus mollis*, dominated by only four genetically different types, one with shoots growing almost half a mile apart. Such clones, capable of continual expansion through great tracts of

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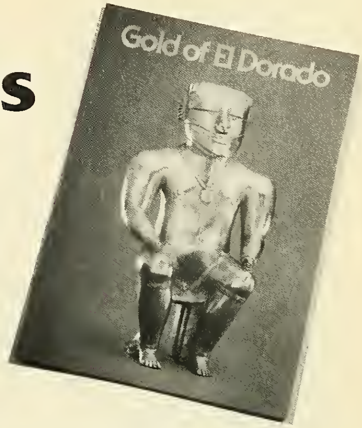
# An Art Book That Took Centuries To Create



It took the American Museum of latural History four years to arrange its xceptional exhibition of more than 500 ieces of ancient gold from Colombia. 3ut those few years are a brief time vhen compared with the decades archeologists have spent digging (literally!) ind studying the gold artifacts from ombs, caves, and buried sites. And all hat time is short when compared with he many centuries prehistoric Indians racticed their craftsmanship and artisry to create these treasures.

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The second challenge for the Amerian Museum was the creation of an ppropriate book to accompany the exibition. We decided against a tradiional catalog; against a small, boring olume with tiny black-and-white picures that could never do justice to these ine objects. Instead, we decided to preent a select number of the finest pieces f pre-Columbian gold in a large, stuning format. And to represent the three mportant elements that make a great rt book we chose outstanding profesionals.

First, photographer Lee Boltin. One f the greatest photographers of art obects, he also took the famous pictures f the Tutankhamun show. We sent him broad to find and record great pieces f pre-Columbian art.

Second, archeologist Warwick Bray, rom the University of London. One of he world's foremost authorities on preolumbian art, Bray is also a skilled writer, able to present fascinating background in a succinct, readable essay in the book. Dr. Bray organized the Colombian gold exhibition in London.

Third, Harry N. Abrams, Inc., America's leading publisher of fine art books. In a co-publishing venture with the American Museum, Abrams designed the book, supervised the preparation of 30 large color plates, and monitored the fine-quality printing.

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space and time must possess phenomenal abilities to withstand the vicissitudes of climate and terrain.

The clonal record for size and age, however, appears to be held by the quaking aspen, *Populus tremuloides*, found in unglaciated portions of the Rocky Mountains in Utah. New shoots are formed by buds that sprout from the roots of a mature tree, and this clonal growth is greatly stimulated when fire or avalanche suddenly destroys the mother stem. Some clonal stands cover such vast regions of rugged mountainside that they were originally mistaken for separate races of aspen. In 1921 Frederick S. Baker of the U.S. Forest Service wrote:

> In the spring when the leaves are unfolding it is commonly noted that the leafing time of adjacent bodies is quite dissimilar. Not infrequently a line can be traced for upwards of a mile through the aspen where on one side the leaves are half developed and on the other the buds are just bursting. This line is almost invariably clear-cut and distinct with little intermingling of the two forms. . . . The writer confesses an entire inability to explain the causes of these two widely distributed, but distinct and closely intermingled races of aspen.

Their true nature remained hidden for fifty years until aerial photographs revealed clones occupying more than 200 acres. One genetic individual was represented by more than 47,000 trees. And the trees were of considerable size and age, one hundred years old on the average. The age of the entire clone is unknown, although in Minnesota, an aspen clone covering several acres probably dates from the last glaciation 8,000 years ago.

Trees that clone usually do so through the production of root sprouts, and many herbaceous plants form new shoots from the main stem through buds that grow for varying distances beneath the ground before initiating a new plant. Other species, such as the succulent herb *Kalanchoe*, are able to fabricate tiny plantlets in notches at the margins of their foliage; these plants eventually fall to the soil surface, begin growth, and establish a colony surrounding the mother.

Somewhat similar in consequence, although different developmentally, is the ontogeny of apomictic, or asexual, seed in numerous species, of which dandelion (*Taraxacum*) and hawkweed (*Hieracium*) have been mentioned. In some cases a cell in the ovary wall, genetically identical to all the other cells in the mother's body, may initiate the normal steps of seed formation. In other species there is a failure in reduction division, the usual process whereby the female egg is created with half the mother's genes in anticipation of fertilization by the equally reduced male pollen. In such instances the egg, containing a full complement of maternal genes, may actually require the chemical stimulation of male pollen without actual fertilization before beginning normal seed development. Apomictic seeds combine the advantages of cloning with the power to disperse offspring great distances.

But what are the advantages of cloning? The answer depends very much on one's perspective. Certainly, plants that are able to survive for thousands of years are doing well by any standards. The problem appears when one tries to decide what is meant by "the plant." Through the eyes of a higher vertebrate unaccustomed to asexual reproduction, the plant of significance is the single stem that lives and dies, the discrete, physiologically integrated organism that we harvest for food and

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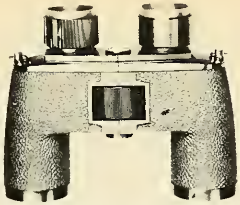
er. From an evolutionary perspecve, however, the entire clone is a ngle individual that, like you or me, ad a unique time of conception and ill have a final day of death when its st remaining stem succumbs to age or ccident.

Natural selection will perpetuate hose combinations of genes that, in a articular environment, manage to surive and replicate identical or closely lated combinations. Clones represent ombinations that have achieved sucess in an evolutionary sense by parating the genetic individual into any different physiological individals. Each of these physiological units ay be termed a ramet, while the entire one, consisting of all ramets derived om a single fertilization of pollen and g, has been aptly called the genet by hn Harper, a plant ecologist at Uniersity College of North Wales. arper has stressed that it is the genet pon which natural selection operates. a large, widespread clone the death f a ramet may have as little evolutiony consequence as the pruning of a ranch in a large tree or the loss of a g in an insect.

Cloning has some definite advanges for species that produce many mets. First, it is a form of growth, increase in size through the initiaon of lateral shoots. As such, it enances the ability of the genet to acuire additional resources and, ultiately, to produce an abundant crop of eds. In this sense cloning is no difrent from a large and healthy tree rowing additional limbs. But while aks and maples produce tall trunks nd overtop other individuals, a preading clone subverts from ithin—or rather beneath. While still ceiving sustenance from the mother lant, a daugher shoot may be able to tablish itself with roots and green foage right in the midst of a dense stand f other individuals.

This is how grasses gradually acuire turf, and the process has been ptly compared to guerrilla warfare. At s leading edge, a large genet, extenvely interconnected, presents an rray of advanced raiders, each provioned by an elaborate logistical netork occupying already conquered terain. The tactical advantage of this ompetitive strategy depends upon the hysiological capability and duration f the supply lines among ramets.

An additional possible advantage of oning—conceptually distinct from e guerrilla tactics—involves spread-



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ing the risk of mortality for the genet among many separate ramets. Here the advantage depends on a physiological and spatial isolation among stems such that the death of a ramet is an independent event. An individual ramet may suffer an alarmingly high probability of dying, but the risk to the genet grows smaller as the number of ramets increases.

This spectrum of benefits—growth, competition, spreading the risk of death—is reflected in the diversity of mechanisms whereby different species grow and reproduce asexually—from the large, integrated clones of prairie and meadow grasses to the floating seeds of dandelions, which are independent from the moment of dispersal from the mother plant. The relations of dependence and independence between mothers and daughters are of considerable ecological and evolutionary interest, but very little work has been done to understand them.

Some interesting experiments have been performed, however, in grasses, such as Italian ryegrass, *Lolium multiflorum*, using carbon dioxide that contains radioactive carbon. The leaves absorb the $CO_2$ and, through photosynthesis, create sugars that are distributed to other parts of the plant, carrying the "hot" carbon with them. By sampling leaves of the mother plant and daughter ramets at different times after exposing the mother to radioactively labeled gas, the experimenter can trace and quantify the supply of nutrients. During the development of a daughter tiller, or ramet, the flow of carbohydrates from the mother gradually decreases as the new shoot initiates its own roots and leaves. Interestingly enough, the umbilical cord does not decay as the flow of resources dwindles, but remains dormant for some time. When the daughter shoot is artificially pruned, maternal sustenance resumes immediately, allowing the injured offspring to produce a new set of foliage.

Similar studies among aspen ramets have shown that the potential for integrated physiologies may survive for years. In the sweet white violet, *Viola blanda* (with which I am working), the ties between mother and daughter last for only three or four years, while the asexual offspring of the starflower are on their own at the end of each growing season.

If clonal growth and reproduction are so successful, why should these species bother with sex at all? While this could be the subject of another essay, I can say that many do not or do so only infrequently. More precisely, one is often hard pressed to find new sprouts from seed in the vicinity of large and successful clones. In the vast tracts of pasture grasses Harberd studied in Sweden, he seldom found a young seedling, and he suggested that, were one to germinate, it would stand little chance of survival among the traffic of vigorous tillers. Anyone who has really looked at such perennial herbs of the forest floor as lilies and wood asters knows that they seldom reproduce by seed. These findings, coupled with the astounding size and age of some clones, suggest that the successful establishment of new genets is a rare event, and that the appearance of seedlings is often associated with some disturbance that removes the competitive advantage of existing vegetation.

A particularly nice demonstration of this can be seen in the work of Eino Oinonen, a Finnish botanist who made an extensive survey of the bracken fern *Pteridium aquilinum* in southern Finland. He first observed that many large clones were growing in the vicinity of villages and road junctions, and after measuring their ground diameter, guessed that their size and age were related. He also knew that the sexual spores of this fern require sterilized soil for germination, a condition often associated with fire.

To confirm his hypothesis of great age and historical origin, he traced the records of encounters between combat troops during the numerous Russo-Finnish wars that periodically brutalized the landscape from the thirteenth century to the Second World War. (In addition to the numerous fires spawned by battle, Russian soldiers baked bread in small ground-pits, which marked their encampments along lines of march.) Remarkably good correlations could be seen between the size of clones found in particular locations and the history of local troop movements.

All of this research suggests the following generalized spectacle of genet and ramet dynamics through time. The curtain rises with the massive destruction of vegetation by some disruptive event such as fire or flood. Numerous new seedling genets germinate from seeds lying dormant in the soil. As it grows and ramifies, each genet sends out runners and advanced shoots (ramets), until contact is made with another genet. The landscape is rapidly occupied by plants, and a long, proracted combat sets in with intertwinng ramets battling for scarce resources f light and nutrients.

Many die at the front, succumbing o prolonged darkness and decay; thers advance, supplied from the rear nd taking advantage of temporary aps in the opposing canopy or patches f disturbed turf. Over long spans of ime, one genet, perhaps not as well dapted to the terrain or with many ewer shoots when contact was made, radually loses more ramets than it can eplace and slowly retreats to more ospitable ground. Numerous small nd imperfectly adapted genets are uickly invaded and conquered. After ix thousand or so years of intense conest only four or five remarkable genets urvive, their precise center of distriution determined more by the accilents of germination than by the perormance of the average struggling amet. Still, at the edges of their terriory they continue to skirmish, each well entrenched and none able to oust he others. Only apocalyptic disaster an terminate the struggle and establish new set of genetically reconstituted ombatants.

Very high drama indeed, but does it eally represent what is happening in ature? There is some suggestive evience. Lin Wu, a student of the Engish geneticist Tony Bradshaw, used lectrophoresis to examine the clone tructure of different populations of edtop, or creeping bent, *Agrostis stoonifera*, which produces clones hrough the vigorous initiation of runers. By extracting proteins chemially and separating them in an electric eld, he was able to determine whether wo plants were likely to be members f the same genet. After extensive ampling and statistical analysis he ould identify the total number of lones in a population.

Bradshaw had long maintained an nterest in populations of grasses growng on soils contaminated with heavy metals, such as lead or copper from ocal mines and refineries. Within hisorical times such grasses had evolved tolerance for the toxic presence of the netals, and Bradshaw suggested to Wu hat he examine the number of genets rowing in grass lawns sown on refinry soils at known times in the past.

He chose lawns that were eight, ourteen, and seventy years old; for a ontrol, he examined the genets of two ntolerant redtop populations growing n uncontaminated soils as lawns of reat but unknown age. To his surprise Wu found that there were many more genets surviving in the refinery populations than in the nontolerant lawns, despite the stringent intensity of natural selection on contaminated soils. In fact, each of the control populations contained only two genets, and Wu and Bradshaw could not believe that this reflected the number of successful seedlings at the time of establishment.

Apparently, extensive genet competition and elimination had long been occurring. Equally surprising, and somewhat puzzling, was the discovery that despite quite different ages all of the tolerant populations were composed of roughly the same number of genets, as though genet warfare on toxic soils had not been occurring.

The explanation came in an examination of the structure of the clones. The eight-year-old redtop consisted of isolated clumps slowly expanding outward. The fourteen-year population displayed coalescing patches of grass initiating contact, with bare islands of soil between. The seventy-year-old lawn was continuous. Wu and Bradshaw speculated that the severe conditions for growth in contaminated soil had accelerated selection for tolerance but delayed the inevitable competitive struggle between tolerant clones. This suspicion was further confirmed when a third, uncontaminated population, growing under harsh conditions near a sea cliff, was found to have a high number of clones. In a sense, then, the adverse conditions of rigorous and stressful habitats may actually maintain a high diversity of genets rather than eliminate them.

We don't know very much about the real biology of most clones growing in nature. Almost no theory and little experimental work has explored the physiological relations of kinship between mothers, daughters, and granddaughters. Determining the consanguinity of a whole community of intermingling shoots is a difficult task at best, and the vast time scale upon which clonal competition appears to be occurring often renders direct tests of historical explanations impossible. But a start has been made, perhaps most importantly in the realization, reflected in the conceptual distinction between ramets and genets, that the laws of natural selection are not constrained by human notions of individuality.

*Robert E. Cook is an assistant professor in the biology department at Harvard University.*

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# The Foxes of Hokkaido

Fox Family, by Minoru Taketazu. *John Weatherhill, Inc., $25.00; 139 pp., illus.*

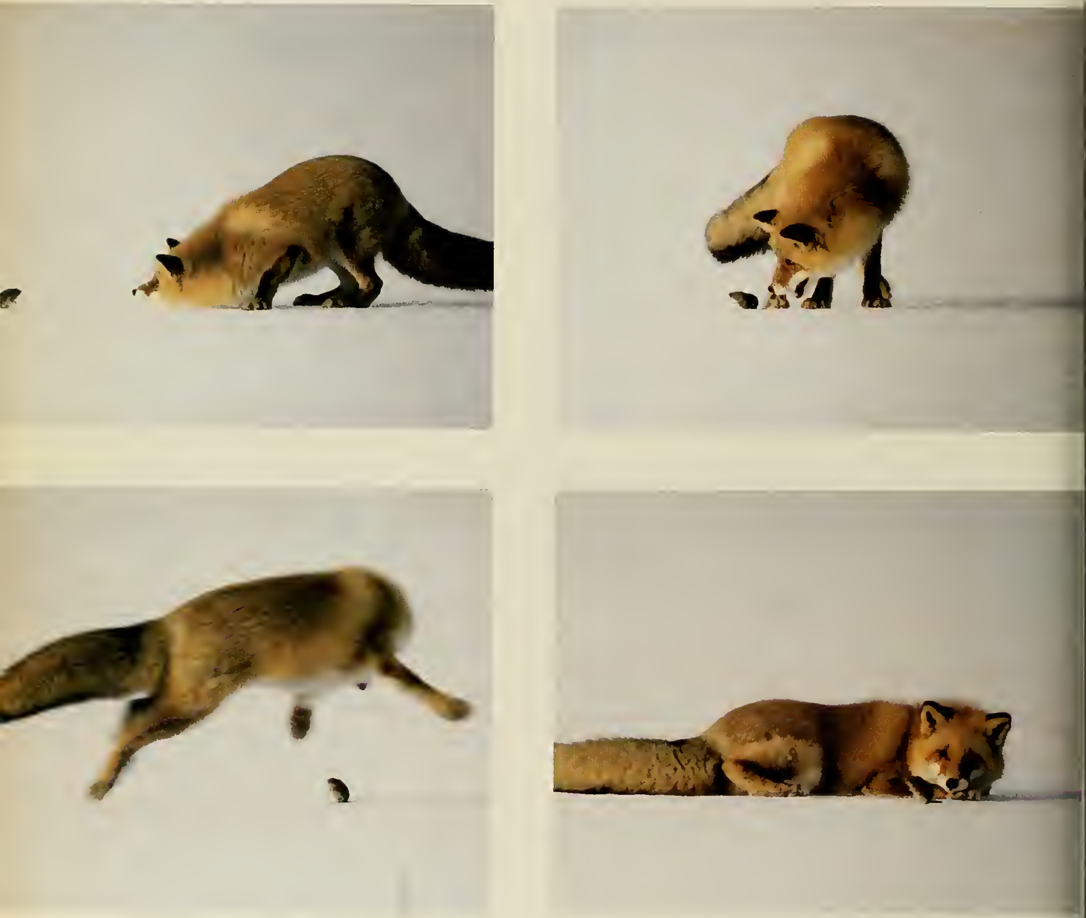
There is a Japanese folk tradition that claims foxes have the power to bewitch human beings, and Minoru Taketazu, author of *Fox Family*, may be living proof of the validity of this old belief. Taketazu, a veterinarian with all the inclinations of a wildlife biologist, has devoted fourteen years to the study of the foxes of Hokkaido, Japan's northernmost island. In 1966, he began observing the Hokkaido fox—a local variety of the red fox—on a regular basis, becoming more and more fascinated with these animals as they became used to his presence and he was able to follow their daily routine. His book presents a seasonal account of their lives, starting with their winter breeding on the ice floes of the Sea of Okhotsk and continuing with the spring birth of the cubs and the rearing and training of the young for the inevitable separation in autumn.

Complementing the narrative and forming the body of the book are remarkable photographs that illustrate the behavior of the fox. Taketazu, who denies he is a professional photographer, spent twelve years taking photographs, and those reproduced in this book were chosen from some 70,000 shots. And what wonderful shots they are: foxes mating, fighting, playing, hunting, romping in dandelion-covered fields, or traveling over a vast, snowy countryside. A series of four photographs shows a vixen, perhaps too full to eat, playing with a mouse much the way a cat does. Many of the photographs center on the cubs, from their first emergence from the den at about two weeks of age through their training to hunt and survive on their own. Foxes have exceptionally well-developed senses of smell and hearing. Detecting the presence of a mouse in the undergrowth, the fox leaps into the air in a graceful arch, then falls on its prey with muzzle and front paws. There are a number of photographs of this hunting technique, apparently more picturesque than effective since the author observed one vixen repeat her leap fourteen times to catch a single mouse. There is such vitality and movement in these photographs that they appear to be the frames of a motion picture.

At the end of the book, there are commentaries for the photographs, keyed to small black-and-white duplicates of the pictures, and a general discussion of vulpine biology.

*Carol Breslin*

*"The vixen's hunting range has extended to the farmlands and the ponds beyond. As I watch her go out, I wonder—probably together with the cubs—what she will bring home for supper. . . ."*



*"On one rare occasion when this vixen was full, she came upon a mouse, and instead of eating it, she observed its motions and did no more than play with it for a few minutes."*

*'Windless days are the best for unting. If they listen carefully, he cubs can hear the footsteps f small animals at the bases of he wild poppies. As soon as they ear a sound, they leap up and ounce on the clump of grass rom which the sound came."*

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# Additional Reading

**Bhutanese Dances** (p. 38)

*The Sacred Dance-Drama of Bhutan*, an informative four-page monograph by Mynak R. Tulka, can be ordered for $4.50 from the Asia Society, 133 East 58th Street, New York, New York 10022. It is part of a packet that includes monographs on Burmese dances and Korean court music and dance. The Asia Society also has a thirty-minute color film, *The Royal Dancers and Musicians from the Kingdom of Bhutan*, for rent or sale. A complete study of the *cham* tradition, *Tibetan Religious Dancers*, by René De Nebesky-Wojkowitz (The Hague: Mouton, 1976), contains the text and translation of an important dance manual composed by the fifth Dalai Lama. Michael Aris discusses the traditions of *cham* in "The Admonition of the Thunderbolt Cannon-ball and Its Place in the Bhutanese New Year Festival" (*Bulletin of the School of Oriental and African Studies*, vol. 39, part 3, 1976, pp. 601–35). *Tibetan Civilization*, rev. ed., by R. A. Stein (Stamford: Stamford University Press, 1972), is on Tibetan culture.

**Toads and Tarantulas** (p. 48)

For a discussion of the relation between some insects and spiders, see "Spider and Fly Play Cat and Mouse," by William G. Eberhard (*Natural History*, January 1980, pp. 56–61). Tarantulas are discussed in *American Spiders*, by Willis J. Gertsch (Princeton: D. Van Nostrand Co., 1949), and in Gertsch's revision of John Henry Comstock's *The Spider Book* (Ithaca: Cornell University Press, 1975). Relationships of toads and tarantulas are mentioned in R. Conant's *Field Guide to Reptiles and Amphibians of Eastern and Central North America*, second edition (Boston: Houghton Mifflin Co., 1975), and in *Reptiles and Amphibians of North America*, by A. Leviton (New York: Doubleday and Co., 1976).

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**Iule Deer** (p. 56)

Well illustrated, *The World of the Vhite-tailed Deer*, by Leonard Lee ue III (New York: J. B. Lippincott o., 1962), draws upon years of data athering for its description of the life f the deer and includes a bibliogıphy. ‘‘Foods of the Rocky Mountain Iule Deer,’’ by Roland C. Kufeld, ı.C. Wallmo, and Charles Feddema JSDA Forest Service Research Paper M-111, July 1973), is a short paper ith an extensive bibliography. A genal book that provides information on iule deer is Raymond Edwin Chapn's *Deer* (Poole: Blandford Press, 977). *The Deer of North America*, lited by Walter P. Taylor (Harrisurg: Stackpole Co., and the Wildlife lanagement Institute, Washington, ı.C., 1956), is comprehensive but ated. A similar work, *Mule Deer and lack-tailed Deer*, edited by O.C. Vallmo will be published soon by tackpole.

**rill** (p. 66)

*The Encyclopaedia Britannica*, fifenth edition, s.v. ‘‘krill’’ in the *licropaedia*, gives a brief description ıd references to articles on ecology, iology, behavior, and the relation of rill to the fishing industry. G. A. lano's article ‘‘Antarctica—the Livıg Legacy,’’ in the *1980 Year Book f Science and the Future* (Chicago: ncyclopaedia Britannica, 1979, pp. 46–71), discusses the role of krill in ıtarctic ecology. A general descripon of the animal can be found in Krill,’’ by J. F. Lohr (*Oceans*, Iay/June 1977, pp. 54–55).

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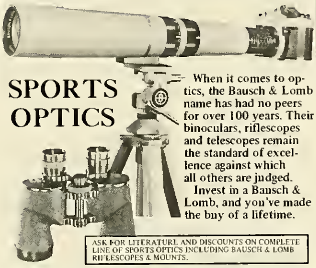

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# The Giant Snail of La Jolla

*Commercial divers, sportsmen, and otters pursue the tasty abalone*

Emma Stark Hampton, Daughter of the American Revolution and the distinguished Michigan lady after whom my Detroit elementary school was named, had in her time put together a stylish amateur collection of rocks and fossils, fish bills, and shells, which came eventually to rest in an unlabeled heap in a disused closet at the Hampton School. The principal, a canny bureaucrat who had been frequently pressed by my mother to "enrich" my educational program, seized upon the neglected Hampton trove as an ideal extracurricular project that would occupy my vaunted intellectual curiosity and also give the school its own museum of natural history.

While other children sat in class, studying the art of the paper wad, I attended to my curatorial duties. Completely ignorant of biology and geology, I spent many happy hours leisurely familiarizing myself with the objects but not making much progress toward their positive identification. Fortunately, an older boy named Larry Fishman, who had a modest grasp of the relevant science, was my cocurator. He knew a trilobite when he saw one, and he was also able to tell me that certain large, flattish, nacreous shells with holes in them were abalones.

In that inland setting, where clams and oysters were exotic beasts, it never occurred to me that the gastropods that had once lived in those iridescent shells were edible. But like many other Midwesterners, when I grew up, I made my way to California, off whose shores various species of the abalone genus, *Haliotis*, cling to underwater rocks and feast on kelp. Californians justly prize the muscular flesh of the foot, sometimes almost twelve inches long, that holds this marine snail in place. Indeed, abalone is such a delicacy along our southern Pacific coast that it is possibly the most expensive indigenous American food, at roughly fifteen dollars a pound in markets, because it is so scarce. Commercial divers and sportsmen with scuba rigs have pursued abalone so avidly that good beds are harder and harder to find. And now that the sea otter is environmentally protected, this natural predator of abalones is extending its range and further depleting the haliotian supply.

This abalone dearth sounds like a typically modern problem in which overfishing, high population density, and ecological tampering have decimated a mollusk that had happily carried on its vegetarian life cycle in American waters for millenniums before the coming of our advanced civilization. This scenario is true enough as far as it goes, but the wholesale assault on the abalone actually began very long ago and must qualify as one of the earliest human depredations of the American biomass.

In the kitchen middens of Indians who lived on what is now Catalina Island, west of Los Angeles, about 4000–3500 B.C., Clement W. Meighan found shell remains indicating that even then, without benefit of high technology, the abalone had started its up-and-down career as a sometimes endangered species.

In the lower strata that he excavated, Meighan found a predominance of abalone shells. They outnumbered the next most abundant genus, *Mytilus* (mussels), by a ratio of 4 to 1. In the upper levels, the ratio had reversed. Evidently, the Indians, preferring the abalone to other shellfish, had eaten their way through the abalone beds and then switched over to mussels when abalones became scarce.

Although contemporary Californians may seem to be repeating the process, they have not yet switched to mussels because of toxic pollution and a dietary phobia against them. Fortunately, they also have taken some measures to turn the tide in favor of the abalone. In a former sardine cannery in Monterey, George S. Lockwood is at work perfecting a commercially viable abalone farm. Through careful, enriched feeding and controlled light and temperature conditions, he hopes that maricultured abalones will put on their desired weight twice as fast as the ten years they would normally take in the wild. Lockwood also sells small abalones to the California Department of Fish and Game, which plants them in the ocean.

More prosaically, Fish and Game patrols set up abalone fishing areas to enforce the strict regulations enacted to protect already established natural beds. Sport divers are permitted a maximum of four abalones a day, and these cannot legally be stockpiled in the refrigerator since it is against the law to possess more than four at a time. There are also rules about minimum permissible length. Red abalones, the largest species, have to be at least seven inches; pinks and greens, six inches. Tougher, less desirable blacks, which

### by Raymond Sokolov

ing to rocks in the surf, are legal at ve inches.

Divers measure their take underater with the irons they use to pry eir prey loose from the rocks. These ng flat blades are marked off at five, x, and seven inches, and by law, they ust not be thinner than an eighth of inch so that they don't cut the abane. Since abalones have no clotting ent in their blood, a cut means cerin death, making it futile for divers put back those that are too small.

Despite all these apparently stultifyg regulations and what may sound e a tedious amount of time spent ecking length, catching an abalone still mostly a matter of stealth and eed. Give the gastropod warning that you are there and it tightens its grip on the rock, tightens it so that its potentially delectable foot exerts a force of 400 pounds per square inch. In practice, once this happens, the game is up: the hapless diver cannot pry the abalone loose. Good abalone hunters slip the blade swiftly under the foot and pull immediately. Hesitation lets the animal seize the blade, and once that happens, hard prying can do little more than bend and break the metal.

"The new diver has a difficult time," says Bert Kobayashi, a Ph.D. in marine biology from the Scripps Institute of Oceanography at La Jolla, who supervises the physical education program at the University of California, San Diego. Kobayashi also teaches scuba classes and is the guiding light of the UCSD diving club, known as the Sea Deucers.

Photographs by Craig Arness

Recently I went with Kobayashi and the Sea Deucers out beyond the famous surf that pounds into Black's Beach in La Jolla. With the town's sheer sandstone cliffs behind us, we pitched and rolled out into the chilly, fifty-degree Pacific in an inflated boat, until we came to a field of kelp. The water was about sixty feet deep where we dropped anchor.

"Right down the anchor line," said Kobayashi in his bass announcer's voice. "Let's do it." Several wetsuited bodies with breathing apparatus flipped backward into the ocean and disappeared except for the constant stream of bubbles they sent up to the surface.

Feeling queasy from the movement of the boat while I sat waiting, I tried to relieve the nausea by staring at distant points on the shore. We had come quite far out to sea, I thought. As Kobayashi had told me, "It has gotten harder and harder to find abalones. There are still areas that appear to be virgin, but even there the average size has decreased."

A pod of curious sea lions swam around the boat, distracting me periodically from the cliffs, which are really the visible portion of an immense undersea canyon whose walls cause La Jolla's splendid surf. Surfers, little black dots much farther in, were out in force riding the big waves.

After a few minutes, Kobayashi emerged with a bag of red abalones, the world's largest *Haliotis*. Some of the other divers had found them too, but the dive had been particularly hard because the surge of the waves had reached down abnormally deep and roiled the bottom, sweeping the Sea Deucers along at a speed that disrupted the intricate search and surgical lunge of abalone fishing. Even so, they had pried loose enough abalones to make a meal for all of us.

After red abalones have been shelled, cleaned, and cut into several thin slices, two of these big univalves will generally feed three people. But getting to the cooking stage with abalones is quite a job and, among other things, requires a grasp of abalone anatomy and physiology.

On the outside of the elliptical shell, near one of the long outer edges, is a line of holes. The animal's gills are behind the holes, which are outlets for water expelled from the gills. There is a lip on the inner rim of the shell on the side with the holes. The opposite side has no lip, giving easier access to the abalone iron.

You set the abalone on a table upside down (with the foot up) and insert the iron between the flesh and the shell, pushing down as far as it will go and then pulling it back and forth while exerting some pressure upward, until the muscle pops loose from the shell. Done properly, this maneuver will remove the abalone in one piece from the shell, which has a beautifully iridescent interior, really a muscle scar where the foot was once attached. Sometimes a tiny, dark shrimp, *Betaeus harfordi*, drops out of the shell. It is a commensal organism, sharing shelter and meals with the abalone.

Along with the muscular, edible foot comes a large blob of gonads—green in females, cream colored in males. Discard these and cut away the black skin and the leathery outer layer of the foot. What remains is a thick wedge of hard abalone muscle. It has to be sliced as thin as possible, which can be done in a trice with a professional meat slicing machine, the kind used in delicatessens. The Sea Deucers had improvised special boards with two metal rods set in them (or in one case, two thin strips of wood). Kobayashi showed me how to set a large, very sharp knife flat on the supports and use them as a guide. With the abalone placed between the knife supports it was possible to slice through the bottom of the muscle, making a transverse cut about an eighth of an inch thick. He removed one slice and then kept on slicing in this manner until the entire muscle had been reduced to several scaloppine, which should be chilled for three hours to relax the muscle. Then you pound them with the same kind of toothed mallet that is sold for flattening veal scaloppine.

This is not an optional step. An abalone cannot be eaten until each slice has been thoroughly pounded into flaccidity. At first, when you pound, the slices curl up as if alive. You turn them over and pound some more until finally you have a docile, extremely thin piece of meat, but you must not pound so energetically that you turn the abalone to mush or cut it to fragments.

Kobayashi soaks pounded abalone slices in milk or beer. Then he dredges them in seasoned cracker meal. Bread crumbs or cornmeal would also work well. Once you have done this, it is at last time to sauté the abalone in hot oil. When they are golden brown, you eat them, saying a little prayer so that conservation and mariculture will prevent the extinction of this very fine gift from the sea.

### Seafood Simmer

(Adapted from *The Northwest Cookbook*, by Lila Gault)

- 4 tablespoons butter
- ¼ cup dry white wine
- 1 tablespoon shallots, peeled and finely chopped
- 1 tablespoon parsley, finely chopped
- 2 large abalones, sliced, pounded, and cut into strips
- 2 large scallops, cut into pieces

1. Melt butter in a medium skillet over medium high heat. When bubbling subsides, add wine and boil for a minute or so.
2. Add shallots and parsley and cook over medium heat for 2 minutes.
3. Add shellfish. Cook for 5 minutes, stirring occasionally.

Yield: 3–4 servings

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

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Take a hair-raising curve and the legendary BMW suspension system—independent on all four wheels—flexes with an uncanny resiliency that makes one feel as if the car were slotted into the roadway.

Press the accelerator and the four-cylinder, 1.8-liter, fuel-injected, overhead cam engine responds in a manner that can only be described as exhilarating, even by pre-pollution control standards.

Yet, the 320i (with 5-speed standard transmission) delivers an impressive $\boxed{25}$ EPA estimated mpg, 36 estimated highway mileage and, based on these figures, an estimated mpg range of $\boxed{383}$ miles and a highway range of 551 miles.

(Naturally our fuel efficiency figures are for comparison purposes only. Your actual mileage and range may vary, depending on speed, weather and trip length. Your actual highway mileage and highway range will most likely be lower.)

## AN INTERIOR ENGINEERED FOR SERIOUS DRIVING.

Perhaps no more succinct an expression of engineering intelligence exists than the interior of the BMW 320i—each facet strategically planned to help prevent driver fatigue.

Vital controls are within easy reach. The tachometer, speedometer and ancillary instruments are well-marked, easy to read and set in a control panel that sweeps out to meet the driver.

Its front seats are designed to hold their occupants firmly in place, and are so thoroughly adjustable that it is all but impossible not to find a comfortable seating position.

All in all, in a time of lowered automotive expectations, amidst increasing mediocrity, the engineers at BMW have actually improved the BMW.

If you'd care to judge for yourself, phone your nearest BMW dealer to arrange a thorough test drive.

**THE ULTIMATE DRIVING MACHINE.**

BMW, MUNICH, GERMANY.

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# SOME THOUGHTS ON REACHING EIGHTY

It is only human, I suppose, to give importance to birth dates and decades, and so we are proud to celebrate the eightieth anniversary of the American Museum of Natural History's magazine, *Natural History*.

Most of the articles in this special issue have been selected from the magazine's first half century. They range from starlings to planets, from the discovery of early humans to the failure to discover the Loch Ness monster. With many articles, a postscript brings these ever changing subjects up-to-date.

The authors, too, are a diverse lot, including explorers, a president of the United States, Museum presidents and directors, and Margaret Mead. The illustrations come mainly from the photographic archives of the Museum's library. Some of the articles have been trimmed a bit because even in the good old days authors tended to ramble on, but in order to preserve the historical flavor of the times, we have not changed the style or manner of presentation. Some regular features also appear in the last quarter of the magazine.

Perhaps a magazine, and especially this magazine, should be wary about emphasizing anniversaries. The month after month publication—with each issue tied to the previous one and influencing the next—seems more like a plant cloned from the root of the mother plant. Certainly, *Natural History* of 1980 is genetically related to its first issues of 1900. And the environment of the Museum has greatly influenced both.

Like a successful species, *Natural History* has evolved during its 682 appearances in eighty years. In typical American fashion, it has grown bigger and fatter with age. This issue is the fattest yet. It has also grown more cosmopolitan both in its subjects and its audience. Its distribution and readership have doubled in the past decade—currently nearly two million people read our half million copies. And with age the magazine has become more colorful and prestigious, if the recognition given last year and this year in the National Magazine Awards and the Society of Publication Designers Competition is a criterion.

Fat, prestigious, proud, and eighty. Are these signs of a magazine in its prime (and therefore nearing its dotage)? Not really. Not if the plans for growth, change, and great future issues are considered. This year *Natural History* will increase its frequency from ten to twelve times a year. It will drop its book bonus and separate calendar, but will include the calendar with a fall issue and two months will be special issues. The 1981 calendar, based on artifacts from the Museum's new Hall of Asian Peoples, will contain some of the most beautiful pictures the magazine has ever published.

If it keeps growing, expanding, changing with the times, yet returning to its roots for direction and consistency, *Natural History* should be around for many more lively decades. In 1900, the Museum's second vice president, Henry F. Osborn (later to become one of its greatest presidents), wrote that the magazine should keep members and the public "informed of all that is going on . . . and [of] the diffusion of natural science." That should keep us busy for the next eighty years.

*Alan Ternes, Editor*

BECAUSE the pale golden glow of our fragile Sauvignon Blanc is an indication of its taste, the winemaker must judge with his eye as well as his palate.

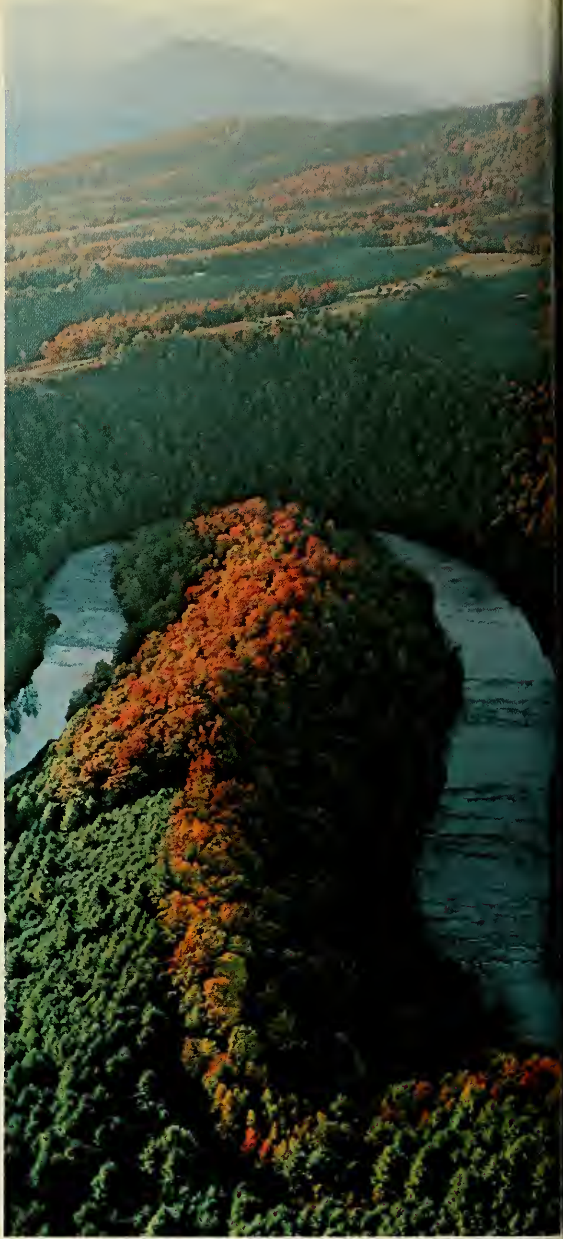
Every step we take, we take with care because THE WINE REMEMBERS

THE WINERY OF
ERNEST & JULIO
GALLO

SAUVIGNON BLANC
of California
THE WINE CELLARS OF
ERNEST & JULIO GALLO

Sauvignon Blanc of Calif.
Ernest & Julio Gallo, Modesto, CA

# COME SEE THE STATE THAT KEPT THE WORLD'S SECOND OLDEST RIVER FROM DYING OF UNNATURAL CAUSES.



Its name, ironically, is the New River. It is 500 million years old.

Older than the first, tentative fishes. Older than the trees.

And, not long ago, it almost went the way of the dinosaurs.

Except for North Carolina, the prehistoric river would be just another man-made lake by now.

But today it flows, unchanged, through gentle hills and fertile valleys. As a part of the National Wild and Scenic Rivers System.

North Carolina, you'll begin to notice from the moment you cross its borders, is a state that takes nature seriously.

You can walk in vast mountain forests that have barely changed since the coming of man.

You can stroll beaches where only the crabs and waterfowl are permitted to take up residence.

From the Great Smokies to the Outer Banks, national and state parks and forestlands cover not just hundreds of square miles, but thousands.

You can camp beside a waterfall, catch your breakfast in a clear mountain stream, and never see a sign of civilization. You can go looking for seashells without having to look at high-rise condominiums. You can run the rapids.

Get soaked to the skin. Go to places you'd never see from the window of a car. Do things you've never done, just because you've never done them.

So come. Enjoy. But do us one favor, please. Try to leave North Carolina the way you found it. Because that's exactly what we're trying to do.

*For more information about North Carolina, and a package of free booklets to help you plan your next vacation, write North Carolina Travel, Department 361, Raleigh, North Carolina 27699.*

**NORTH CAROLINA**

# Authors

**Rudolph Martin Anderson** (1876–1961), born in Iowa, became a Canadian citizen and joined the staff of the National Museum of Canada in Ottawa in 1913. From 1920 until his retirement in 1948 he was chief of the Division of Biology. Anderson served as zoologist and chief of the southern party on the Canadian Arctic Expedition of 1913–16, led by Stefansson, and later edited the sixteen-volume *Reports*, detailing the scientific results of that venture.

**Richard E. Byrd** (1888–1957), a naval aviator, was perhaps America's most famous and controversial polar explorer. His claim to have flown over the North Pole in 1926 was later disputed on the ground that his plane was incapable of making the flight within the reported elapsed time. A year later, with three companions, he flew across the Atlantic Ocean. In the late 1920s, Byrd established a base camp in Antarctica, called LITTLE AMERICA, from which he explored the continent. In 1955, he was put in command of all United States antarctic activities.

**Roy Chapman Andrews** (1884–1960) joined the staff of the American Museum in 1906. At the beginning of his career, he specialized in the study of whales and other aquatic mammals. During the First World War, he called the attention of the U.S. Food Administration to the possibility of using whale meat as a food source (it was then being used as fertilizer). As the Museum's assistant curator of mammalogy and, then, as curator-in-chief of the division of Asiatic explorations and research, Andrews led three expeditions: to Tibet, southwest China, and Burma (1916–1917); to northern China and Outer Mongolia (1919); and to central Asia (1921–1930). He served as director of the Museum from 1935 until 1942, when he resigned in order to write. He lectured widely and was the author of numerous books.

**Harold Elmer Anthony** (1891 1970) came to the American Museu in 1911. He was chairman of the D partment of Mammalogy from 1942 t 1958 and deputy director of the Mu seum from 1952 to 1957. Expeditio were a hallmark of his life, and he le collecting trips for the Museum to e ery continent except Australia. He r tired in 1958 and served until 1966 a curator of the Frick Laboratory, a fo sil research laboratory associated wit the Museum. Among the specimens h collected for the Museum were edibl orchids, legless amphibians, a Mon golian mummy, and a barking deer

**Frank M. Chapman** (1864–1945) served with the American Museum fo fifty-four years. He was trained as banker but a voluntary assignmen dealing with the spring migration o birds in 1884 propelled him from a career in banking to one in ornithology He joined the Museum in 1888, jus before the "big blizzard," and became curator of ornithology in 1908. Chapman originated the concept of the "habitat group," which revolutionized the showing of animals in museums. A popular writer on birds, his *Handbook of Birds of Eastern North America* reached three editions in the year it was published, 1895.

# 1980 FORD BRONCO

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Exciting news for 1980: Bronco introduces Twin-Traction Beam, the only truck in its class with independent front suspension. Feel the difference on the road. And off.

Ford's new design Bronco gives you the best estimated mpg of any V-8 4-wheeler. Trim new size outside for easy maneuvering. All-new nterior with more front leg room, improved climate control, new anti-theft features.

Bronco's built tough on a truck chassis, tested tough at Ford's Arizona Proving Ground. Test it at your Ford Dealer. Ask about Ford's corrosion perforation warranty. It's a no-cost 36-month limited warranty that excludes exhaust system components. And ask about Ford's Extended Service Plan, too.

**BEST V-8**
**ESTIMATED MPG**

**15 mpg**
EPA EST.*

Optional 5.0L (302 CID)
V-8 with automatic transmission.

*Compare this estimate with others. Your mileage may differ depending on speed, distance and weather. California excluded.

Built Ford Tough

**Roomy interior** has all-new styling, options like tilt steering wheel, reclining Captain's Chairs up front, AM/FM stereo with cassette or 8-track tape player.

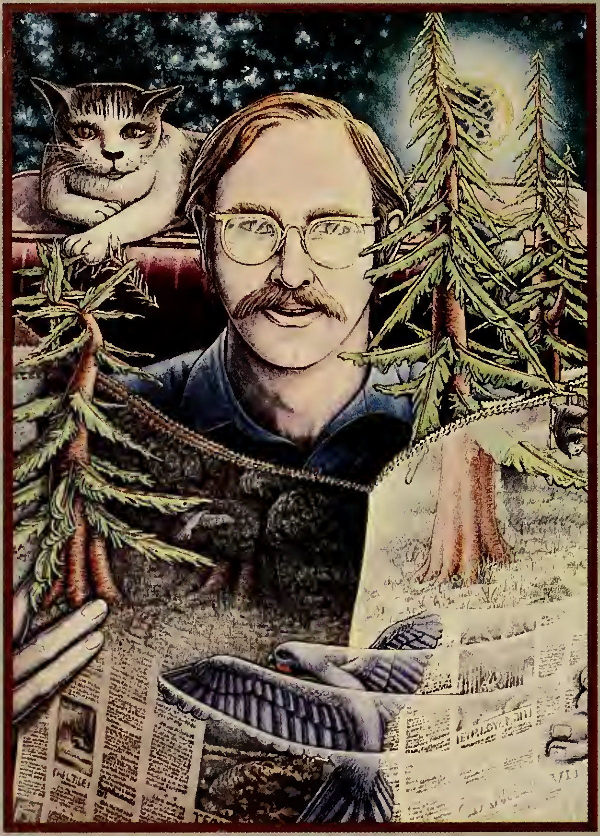
**New Bronco choices** include six roof colors. Above: Landau Tu-Tone with accent tape stripe. At top: Free Wheeling Bronco shown with optional tri-color tape stripe, styled steel wheels, RWL tires, and more.

**Independent front suspension** eases wheels over bumps separately to give a better ride than last year. Helps off-road control.

FORD

FORD DIVISION Ford

## What do you see when you look at your newspaper?



It depends on your point-of-view.

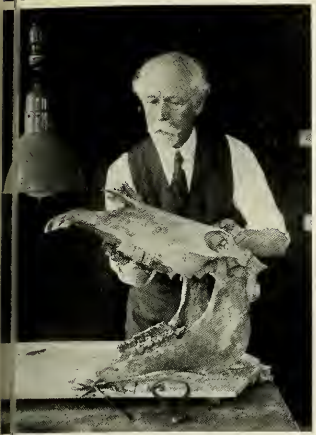
You might see a timely source of useful information, jobs for many people, or the short-lived ghost of a once-proud tree.

We see these things, and more. We see a big part of a business our employees and shareholders depend on. We're one of the world's leading suppliers of paper products.

We also see the trees that stand behind these products, and we strive to manage them in a way that reconciles your viewpoints, so that we can provide satisfactory jobs, products, profits and thriving trees.

If we succeed, everybody wins. Reason enough to try, don't you think?

**Boise Cascade Corporation**
A company worth looking at.



**Samuel H. Chubb** (1863–1949) was dicated to the craft of mounting sletons of horses and other animals i ifelike, active poses. In 1892 he sold h first animal skeleton to the Americ Museum, where he pursued his scial interest up to the time of his ath fifty-seven years later. He was ierviewed for *Natural History* in 123 by A. Katherine Berger, the gazine's assistant editor.

**Theodore D. A. Cockerell** (1866–48), an entomologist, was a prolific ntributor to scientific journals, rticularly on the subject of bees, a elong passion of his. By 1938 ckerell had published 5,840 new mes for species, subspecies, and rieties of bees. From 1888 to 1945 he blished more than 1,200 scientific pers (a few were coauthored). He so developed the red sunflower, a dely known variety, from a single ld plant discovered by his wife.

**Edwin G. Conklin** (1863–1952), professor of biology and chairman of the Department of Biology at Princeton University from 1908 until his retirement in 1933, did important research in embryology and helped establish the field as a discipline in its own right. In addition, he wrote extensively on Darwinism and lectured on the relations between science and ethics. He was a strong supporter in the early 1900s of the young field of experimental biology. Conklin's book review reprinted here is of a work by Thomas Hunt Morgan, one of the pioneer experimental geneticists.

**Raymond A. Dart** (1893–) was a professor of anatomy at the University of the Witwatersrand in Johannesburg, South Africa, in 1925 when he received a fossil skull found by a miner. On examination of the skull, Dart's conclusion was that he had found a new fossil species, *Australopithecus africanus,* intermediate in its characteristics between apes and human beings. Dart retired in 1959 as a professor emeritus and still lives in South Africa; he celebrated his eighty-seventh birthday February 4.

**Lincoln Ellsworth** (1880–1951) was a wealthy engineer, explorer, and adventurer, who financed many expeditions himself. He led the first transarctic air crossing in 1926 and in 1936 was the first to cross Antarctica by air. Twice he financed and accompanied Roald Amundsen, the Norwegian explorer, in polar air explorations. During four expeditions to the Antarctic, Ellsworth claimed a total of 300,000 square miles for the United States.

**Clyde Fisher** (1878–1949) was a member of the scientific staff of the American Museum for twenty-eight years and curator-in-chief of the Hayden Planetarium from its opening in 1935 until his retirement in 1941. He organized the Museum's Department of Astronomy in 1924 and campaigned for ten years to get its planetarium built.

**Amadeus W. Grabau** (1870–1946), for twenty years a professor of paleontology at Columbia University, was a leading figure in both paleontology and geology. He pioneered advances in stratigraphy, set forth the principles of the field of paleoecology, and supported an early theory of continental drift. In 1920 Grabau moved to China, where he spent the rest of his life. He became professor of paleontology at the National University there and chief scientist of the Geological Survey of China.

**William K. Gregory** (1876–1970), an ichthyologist and paleontologist, joined the American Museum in 1899 and retired in 1944. His specialty was the anatomy and dentition of fish and mammals. During the course of his long career at the Museum he served as curator of ichthyology and comparative anatomy and planned and supervised a number of exhibits.

**George Bird Grinnell** (1849–1938) was an American naturalist prominent in conservation movements. In 1886 he organized the first chapter of what later became the National Audubon Society, and in 1896 he helped found the New York Zoological Society.

**David Starr Jordan** (1851–1931) was the first president (in 1891) of Stanford University. He came there from Indiana University, where during six years as president he instituted such innovations as elective courses and a major field of study for students. Jordan's discipline was ichthyology, and he studied fish of the Pacific coast, the Gulf Coast, Florida, Cuba, and the major American rivers. His ideas on speciation, reprinted here, grew out of early field trips in the southern United States.

**William D. Matthew** (1871–1930
curator of vertebrate paleontology a
the American Museum when the art
cle reprinted here was first publishe
spent more than thirty years at th
Museum, starting in 1895 as an assis
tant in the Department of Vertebra
Paleontology. He left in 1927 to be
come curator of the Paleontologica
Museum of the University of Califo
nia. Matthew wrote frequently fo
*Natural History* on paleontology an
evolution.

**Margaret Mead** (1901–1978) bega
her fifty-year association with th
American Museum in 1926 as assis
tant curator of ethnology in the De
partment of Anthropology. A teache
writer, and lecturer, she was know
throughout the world for her researc
in the South Pacific and as a com
mentator on contemporary social is
sues.

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**Henry Fairfield Osborn** (1857–1935) became president of the American Museum of Natural History in 1908 and kept that position for twenty-five years, presiding over a period of great growth for the Museum. He came to the Museum from the faculty of Princeton University in 1891. In that year he founded both the Department of Biology at Columbia University and the Department of Vertebrate (then Mammalian) Paleontology at the Museum. Although his original scientific work was in vertebrate paleontology, his interests were wide and included conservation. Osborn developed a comprehensive theory of evolution that few scientists accepted. He fought against the Tennessee antievolution statute that resulted in the famed Scopes monkey trial. And, like some other scientists of his time, including Edwin G. Conklin and David Starr Jordan (also represented in this issue), he had a strong interest in eugenics, the improvement of the human race through selective breeding.

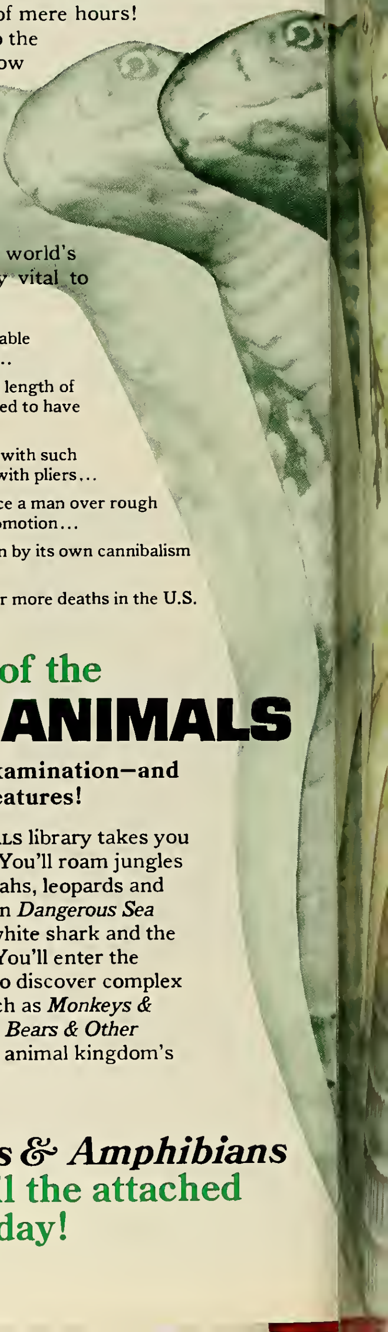
**Chester A. Reeds** (1882–1968) became curator of the Department of Geology and Invertebrate Paleontology of the American Museum in 1925 and served in that capacity until 1938. His association with the Museum first began in 1910, after a brief stint as a lecturer in geology at Bryn Mawr College. Reeds was born in La Cygne, Kansas, and received his Ph.D. from Yale University in 1910. A Fellow of the American Geological Society, he published extensively in his field.

**Theodore Roosevelt** (1858–1919), twenty-sixth president of the United States, had a lifelong interest in natural history. As a conservationist, he was instrumental in reserving millions of acres of land for public ownership. Contributing to his reputation as an outdoorsman is the story of how, on a Mississippi bear hunt, he refused to shoot a bear that had been captured as a trophy for the White House. The incident was popularized in a 1902 newspaper cartoon and inspired the creation of the ever popular Teddy Bear.

**Vilhjalmur Stefansson** (1879–1962), the Canadian explorer and ethnologist, depended for the success of his Arctic expeditions on living off the land according to Eskimo ways. He wrote several books about his explorations, including *My Life with the Eskimo, The Friendly Arctic, Unsolved Mysteries of the Arctic,* and *Discovery.*

**Gilbert L. Wilson** (1869–1930) spent two months of each year, from 1908 to 1918, among the Hidatsa, or Gros Ventre, Indians, gathering information about their culture for the American Museum. He published monographs on the dog and horse culture complexes of this tribe. Wilson looked upon the narrative, and the demonstrations accompanying it, as data, to be set down verbatim. His method was to control the narrators as little as possible, merely holding them to a description of actual personal experiences. At the time of the work reprinted in this issue he was a graduate student in anthropology at the University of Minnesota.

# KING COBRA



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- **Anaconda,** a constrictor which grows to a length of more than 25 feet (one such snake was reported to have devoured a five-foot caiman—whole!)...
- **Gila Monster,** which hangs onto its prey with such tenacity, it sometimes can only be torn loose with pliers...
- **Racer Snake,** which can easily outdistance a man over rough terrain by means of a complex serpentine locomotion...
- **Crocodile,** slowly driven toward extinction by its own cannibalism of its young...and man's greed for its hide.
- **Eastern Diamondback,** responsible for more deaths in the U.S. than all other snakes combined...

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*MAY/JUNE 1927*

# NORTH TO 88 AND THE FIRST CROSSING OF THE POLAR SEA

BY LINCOLN ELLSWORTH

*"When one goes forth a-voyaging*
*He has a tale to tell."*

IT had always been Capt. Roald Amundsen's wish to fly to the North Pole, and there if possible, abandon one plane in order to refuel the other from her, and with the remaining plane go on to Point Barrow, Alaska. Because the interest of us both lay, not in the attainment of the Pole—Peary having already been there—but the exploration of that great million square miles of unknown Polar Basin beyond, we took this into consideration in planning our 1925 flight from Spitzbergen with two aëroplanes.

The story of our flight over the Polar Sea to within 120 nautical miles of the Pole has already been told. Although we didn't reach the Pole, the flight had shown that the meteorological conditions prevailing over the Polar Basin offered no hindrance to its successful exploration by means of the proper kind of aircraft.

After our experience with airplanes we decided to buy an airship, and we went to Italy because Mussolini had one that appeared to fit both our needs and the size of our purse.

The N.1, built to the designs of Col. Umberto Nobile in the Italian State Airship Factory, and christened by us the "Norge," was of semi-rigid construction, 349 feet long and of 20 tons displacement. Her fuel capacity of 7 tons, to run her three 250 horse-power Myback motors, gave her a range of 3500 miles, or about 70 hours, at a speed of 50 miles per hour. Her gas capacity of 660,000 cubic feet was about ⅓ that of R.33.

The "Norge" was equipped with a Marconi wireless direction finder, the tuning-circuit for which was designed to cover a wide band of wave lengths; those used ranged from 900 to 1400 meters. The energy for the specially constructed valve transmitter was delivered from a windmill-driven generator supplying 3000 volts.

There was a delay of several days after the long flight from Italy to Spitzbergen, before the "Norge" was able to proceed on her journey across the Polar Sea. Favorable weather conditions were essential. We needed a clear sky with good visibility, and a favorable wind; also a high barometric pressure and a low temperature. These last two elements influenced greatly the lifting capacity of the dirigible. For each degree Fahrenheit that the temperature went down, the airship gained 80 pounds in lifting capacity, which was increased by 140 pounds for each tenth of an inch added to the barometric pressure.

The keel of the "Norge" looked like a flying storehouse when all was ready for the start at 8.55 o'clock on the morning of May 11, 1926. The equipment included tents, sleeping-bags, skiis, snow-shoes for those who couldn't ski, rifles, shot-guns, ammunition, a hand-sledge—the finest piece of workmanship I ever saw—made by Oskar Wisting on the "Maud," and a canvas boat. Two men among the personnel, Amundsen and Wisting, had the distinction of having been at the South Pole, and now both were en route for the North Pole.

Provisions consisted of pemmican, chocolate, oat biscuits, and dry milk, sufficient to last 16 men two months, with a daily ration of 500 grams for each man.

On the walls of the cabin hung the pictures of Norway's King and Queen, presented to the "Fram" on the expedition to the South Pole in 1910; an image of the Madonna which the Italians had brought with them; and a four-leaf clover given to the ship by Major Scott, who piloted the British airship R. 34 across the Atlantic. In the keel hung the flags of Norway, the United States, and Italy, to be dropped on the North Pole.

To those who made the first crossing of the Polar Sea it will ever be "life's great adventure," for in all human experience never before has man traveled so fast and so far into the realm of the unknown. There is an indefinable something about such an experience, where illusion and reality are so hauntingly intermingled, that ever after it may well color one's whole sentiment of existence.

Two hours after leaving King's Bay we found ourselves over the "pack-ice." What weather! The sun shone brilliantly out of a sky of pure turquoise, and the whalelike shadow that our airship cast beneath us trailed monotonously across a glittering snowfield, unbroken, save where wind and tide had rift the icy surface into cracks and leads of open water. Three white whales darted under the protecting shelf of an ice-floe, and polar bear, frightened at the sight and noise of the weird monster that took to the air instead of the sea, dived into the sheltering leads, sending up columns of spray that reflected the bright sunshine.

As we approached latitude 83½ the snow-crowned peaks of Spitzbergen merged into the deepening blue of the southern sky, losing their identity, and all signs of life vanished. Intermittent fogs rolling beneath us like a great woolen ocean, hid the ice from our view. Approaching 88 we had to rise from 1800 feet to more than 3000 in order to get over it. Latitude 87.44—what memories! The motors were slowed down in commemoration of our sojourn there the year previous, although we were passing the exact spot 50 miles to the eastward.

In this latitude, during the summer months, it is difficult to separate days and nights, for the sun swings

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around the horizon at practically the same altitude during the entire twenty-four hours. But our Greenwich chronometer told us we had been out 16½ hours, so the time was really 1.30 A.M., May 12. The fog had completely cleared away and there was no wind. The navigator who had been on his knees at one of the starboard windows since 1.10 with his sextant set on the height and declination the sun should have at the Pole, corresponding to the given date, suddenly announced, "Here we are!" as the sun's image started to cover his sextant bubble. We were over the North Pole! With motors throttled and heads uncovered we descended to within 300 feet of the ice and dropped three flags.

"There is no more evanescent quality in an accomplished fact," says Conrad, "than its wonderfulness." Solicited incessantly by the considerations affecting its fears and desires, the human mind turns naturally away from the marvelous side of events. And it was in the most natural way possible that, after crossing the Pole, we filled our mugs with meat-balls immersed in a liquid of hot grease, from a large thermos cask, and, squatting down anywhere out of the way of trampling feet, devoured the first and only hot meal of our entire voyage from Spitzbergen to Alaska.

With full speed ahead we settled down to the monotony of routine again, heading southward instead of north, with the sun-compass settled for Point Barrow, Alaska, 1500 miles away. Ahead lay the world's biggest unexplored area. What would it reveal, a lost continent, islands, or what? Would we cross safely to tell the world what we had seen? Hour after hour passed, but only the same glittering surface rift by wind and tide into cracks and leads of open water, was here as before crossing our route, in a west-east direction. We reached the "Ice-Pole" at 7 A.M., five and one-half hours later.

This "Ice-Pole," so called because it is the center of the Arctic ice-mass and therefore the most nearly inaccessible spot in the Arctic regions, lies in latitude 86 N. and longitude 157 W. But its inaccessibility was now conquered.

We had covered one half the distance between King's Bay and Point Barrow. Of the seven tons of fuel the ship carried, only about two tons had been consumed. Here, strange to say, we picked up the first sign of life since leaving 83½ (almost 700 miles), one lone Polar bear track. What a challenge! What a mockery to our egotism! Yet there it was, plainly crossing a large ice-floe. Only a Polar bear, but something alive and like ourselves seeking—but what, away out here? Anyway, it was something tangible again. The sense of utter solitude—the illusion of disembodiment—that had taken possession of me, as I seemed to float through the void like a lost soul, beyond the confines of a three-dimensional world, vanished, and in its place sprang eternal hope and the desire to achieve.

Just ahead, so it seemed, lay Alaska, the goal of our dreams. "A little more, yet how far it was; a little less, but what worlds away." But as we approached its coast, fears assailed us; for we ran into the only storm during our entire voyage—fog, wind, and sleet—and for thirty-one hours we battled. Ice coated the aërial wire and froze the windmill driver of our generator, which supplied the electrical energy to operate the transmitter and charge the storage batteries, and all efforts to establish communication with Alaska were of no avail.

Ice-crust formed on the bow of the ship. This was alarming, not only because it loaded her down, but also because it spoiled her trimming. We tried to counteract the effect by moving the fuel from the bow tanks and sending the crew aft. Needless to say, our greatest danger lay in the ice that was torn loose from the sides of the ship by the whirling propellers and thrown against the gas bags. An ice-block of the most fantastic shape settled on the sun compass, stopping the clockwork and putting it out of action for the rest of the flight.

It was a surprise, therefore, to find by observation at 4 A.M., on May 13, that we were in a nearly north-south position on a line striking the Alaskan coast and passing only twenty-one nautical miles west of Point Barrow, because it had been nearly twelve hours since the last longitude observation. At 6.45 A.M., land was sighted ahead on the port bow, and at 7.25 after a voyage lasting 48 hours, we reached the coast. Flat and snow-covered, it was the most desolate looking coast line imaginable, but it was land and that was enough.

As we passed over the coast line the fog became denser and denser, obliging us to go lower and lower in order to be able to see far enough ahead so that we would not run against obstacles. At last, abreast of Cape Beaufort, it became impossible to see any longer, and we rose through fog and cloud into bright sunshine. Heavy layers of fog drifted beneath us, and only now and then through openings in it could we glimpse the barren peaks of the Endicott range, over which we were passing—far too little to enable us to make out our whereabouts.

When we believed ourselves as far south as we could go, we tried to get down underneath the fog and do our best to find the way. We had to nose down to an elevation of only three hundred feet before we could see what lay beneath. We were over drift-ice again. Where were we? Unreal as it may seem, our wireless picked up a strong signal at this moment, which we thought might be Nome but we could not tell for certain, because it was a communication with another station and we couldn't get the signature. But it gave us a position north of Diomede Island and enabled us to set a course for Cape Prince of Wales.

Very soon we were over open water which aroused our suspicions, for we might just as well be on the outside of Bering Strait and, with our course, heading straight for the Aleutian Islands. Getting into sunshine again we were obliged to take our observation from the top of the ship, as the sun at this latitude was so high that it was hidden by the envelope in whichever direction the ship pointed. The observation gave our latitude as 67.30. We then went down through the clouds and found ourselves over land, having passed over the whole of Kotzebue Bay, driven by a northerly gale of more than 70 miles per hour. Heading west to get to the sea again, we heard the Nome wireless, which together with the identification of the coast line, gave us our exact position.

At 3.30 on the morning of May 14, we rounded Cape Prince of Wales, and, tired but happy, brought our airship, coated with a ton of ice, safely to rest at the little trading post of Teller, 91 miles northwest of Nome, after a journey of 3393 miles, lasting seventy-two hours, across the Polar Sea from Europe to America.

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Amundsen was the first to navigate the Northwest Passage by ship. He did that in 1903–06, about a decade before the flight described here. In 1969, following the discovery of oil in northern Alaska, the S.S. *Manhattan,* an American ice-breaking tanker, became the first commercial ship to sail the Northwest Passage.

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And while debate over passive-safety restraint systems drags on, you can buy a Rabbit "L" with a system that meets the 1984 safety requirements today.

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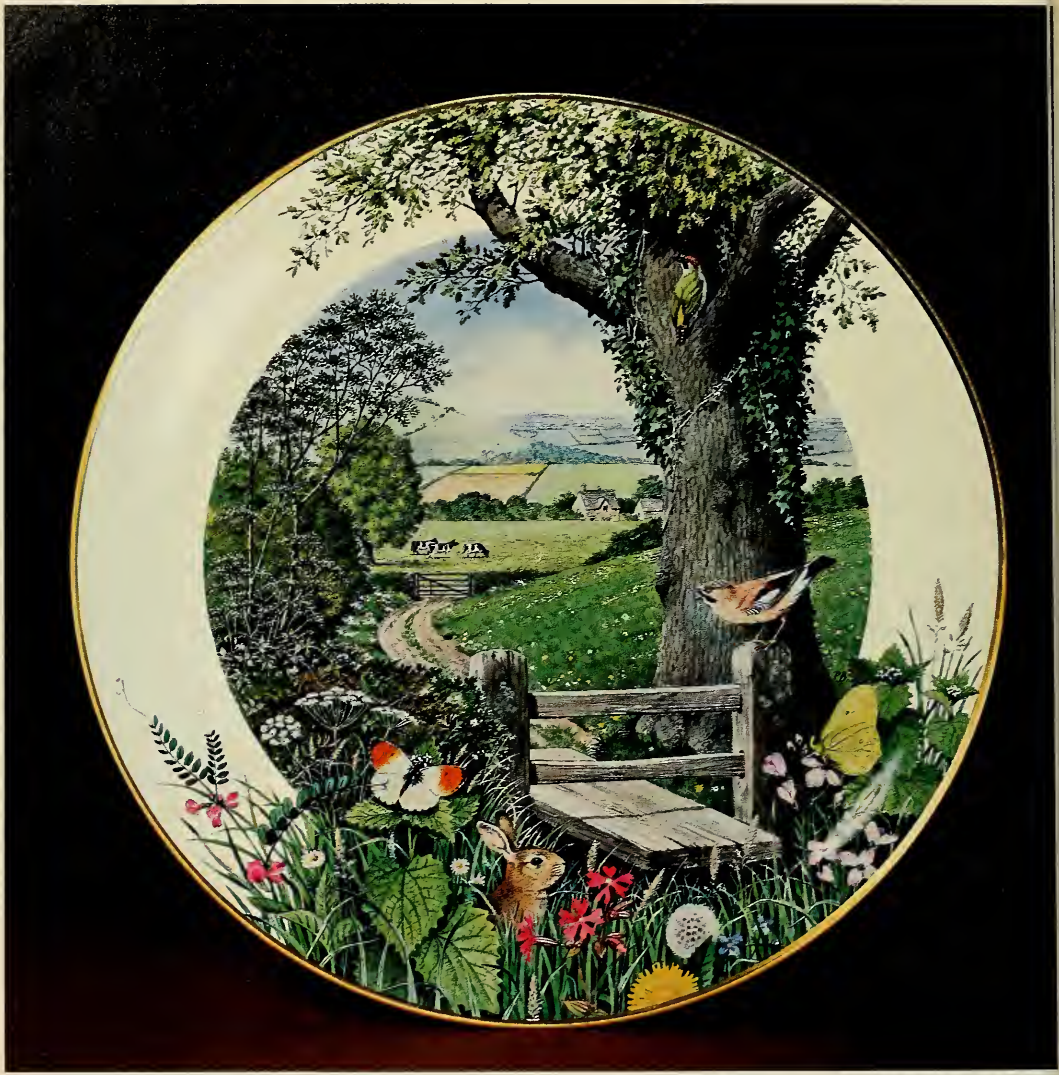

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A Country Path in May

Plates shown smaller than life size. Actual diameter: 9 inche

IN FINE ENGLISH PORCELAIN…

# The Country Year

BY PETER BARRETT

*A collection of twelve beautiful porcelain plates, each portraying the charm and color of the countryside in a different month of the year.*

*Each plate bears an original work of art and is individually decorated with pure 24 karat gold.*

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**To be issued in limited edition.**

**Offered by direct subscription only, with a further limit of just one collection per applicant.**

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---

The beauty of a mountain stream in autumn, or a country meadow dappled with summer sun, possesses an enchantment that is universal. And it is the rare ability to capture this unique form of visual poetry — the beauty of the ever-changing countryside — that has established the English painter Peter Barrett as one of today's most gifted landscape artists.

And now, for the first time in his career, Peter Barrett has undertaken the task of creating a collection of important new works for issue in a form particularly prized by collectors: a series of twelve beautiful *porcelain plates* portraying the entire panorama of the countryside.

Each of these original works has been commissioned by Franklin Porcelain and created *exclusively* for 'The Country Year' porcelain plate collection. After it is completed, none of these plates will ever be issued again.

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The April plate, for example, conveys the loveliness of Spring from the perspective of a secluded bluebell bower . . . The spirit of May invites us to follow a quiet country lane . . . August brings us to a golden wheatfield, where swallows swoop low in search of food . . .

Wheatfields in August

The Colors of Autumn in October

No detail, no matter how small, escapes Peter Barrett's eye. Yet, over and above their sheer beauty, these new works accomplish something even *more* extraordinary. Because each plate actually seems to draw the viewer *into* the scene.

***Challenging to create . . . satisfying to own***

By letting elements of his art burst out of the center of the plate and flow to its very rim, Peter Barrett has given these works a unique sense of depth and dimension . . . a feeling of movement and vitality that brings *life* to every scene.

Furthermore, because of the precision of Barrett's art, and the fact that he has used some twenty-five separate colors in every work, this is a collection as challenging to create as it is satisfying to own. Indeed, more than two years has been devoted to its preparation.

To provide full scope for Peter Barrett's artistry and vision, each plate will measure a full nine inches in diameter. The entire collection will be crafted of fine English porcelain, whose traditional richness and vibrancy are exceptionally well suited to dramatizing the subtle colors of his art. And each scene will be framed within a decorative circular border of *pure 24 karat gold.*

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Each of the twelve beautiful plates in the collection is a superlative work of art in itself. Together they constitute a gallery of fine art that is breathtaking. Displayed upon the wall or shelves of any room, these beautiful plates cannot help but enhance the decor of your home.

But the plates are being made available on a very limited basis. They will be crafted *exclusively for individual subscribers.* And a further limit of just one collection per subscriber will be enforced without exception.

Here in the United States, the collection will be issued in a single edition, available *by direct subscription only* — and only from Franklin Porcelain. One plate will be issued every other month, and the issue price is just $55 for each plate and individual wall hanger.

Because of the international interest in Peter Barrett's art, a second edition will be made available overseas, with equally stringent limitations. In the tradition of the finest porcelain, the collection will be available only until the end of 1980, at which time the subscription rolls will be permanently closed. To enter *your* subscription, you need send no money now. But the application below must be mailed by April 30, 1980.

OUR PROMISE TO YOU: Franklin Porcelain takes pride in the excellence of its limited edition works of art. Therefore you may return any plate in this collection, for any reason, within 30 days after it is sent to you and receive a full refund or credit.

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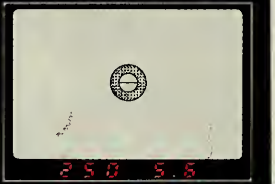

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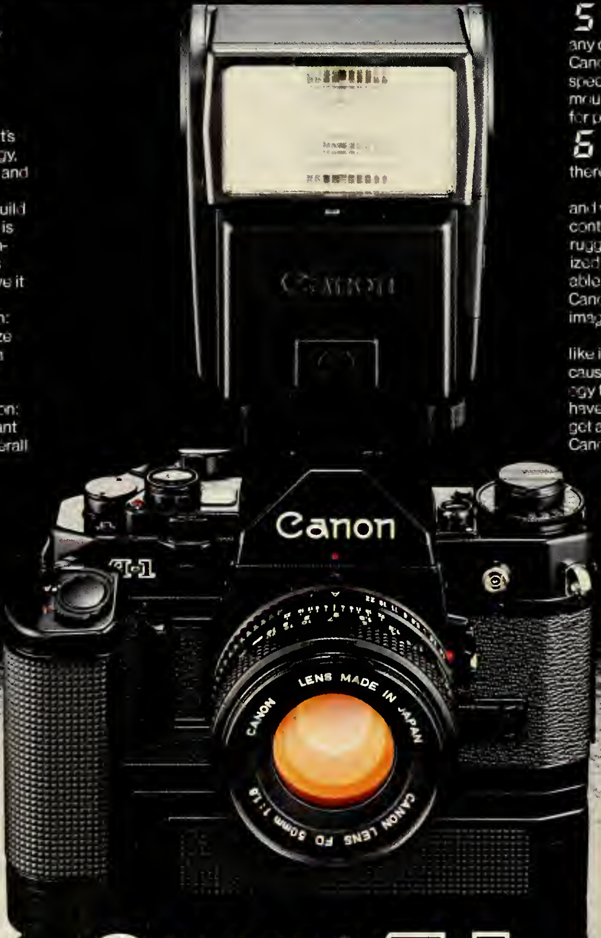

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*MAY/JUNE 1934*

# THE HAYDEN PLANETARIUM

The New Addition to the American Museum Which Will Contain the Latest Example of the Most Wonderful Device Ever Developed for Setting Forth Realistically and Impressively the Motions of the Heavenly Bodies

By CLYDE FISHER

WHY did not somebody teach me the constellations, and make me at home in the starry heavens which are always overhead and which I don't half know to this day?"

There will soon be no excuse for those living in the metropolitan district of New York to utter this plaint of Carlyle's, for in spite of smoke, haze, clouds, and the glare of artificial lights, they will have opportunity to become familiar with the night sky, thanks to the new Hayden Planetarium which is coming to the American Museum of Natural History. This realistic representation of the sky is evidently more important to the city dweller than to the suburbanite, since the case of the former is further complicated by the fact that a great portion of the sky is hidden by the ever-present tall buildings.

Devices to show the movements of the planets and our moon in relation to the sun have been constructed since the early days of Copernican astronomy, and no doubt previous to the announcement of the sun-centered theory of our solar system, there were devices to illustrate Ptolemy's earth-centered system. As early as the latter half of the Sixteenth Century, the great Dutch astronomer, Huygens, and the great Danish astronomer, Roemer, built a planetarium to represent the solar system, as it was then known, according to the new Copernican theory, and doubtless this invention had much to do with the general acceptance of the sun-centered notion of our family of worlds.

After the general acceptance of the Copernican theory of astronomy a great variety of instruments was made for the purpose of showing the relative motions of the then known bodies in our solar system—many of them crude, but for the most part very helpful. Some were limited to the earth and sun and moon, others just to the earth and the moon, and still others to the sun and all the known planets and satellites.

One of the most interesting and complicated of these early instruments was built in England for Charles Boyle, the fourth Earl of Orrery, and this one gave us a new word for our dictionaries. The word "orrery" has come to be applied to this type of planetarium.

The most famous orrery or planetarium of this type to be made in America was devised and built by the "Father of American Astronomy," David Rittenhouse of Philadelphia. It is one of the most highly prized of the historical astronomical instruments in the Franklin Institute in Philadelphia, where it may now be seen.

Probably the largest, and certainly one of the best of these old-fashioned Copernican planetariums ever made is installed in the world-famous Deutsches Museum in Munich.

These planetariums or orreries consisted of a series of globes to represent the various bodies of our solar system, each revolving globe supported by a metal rod, the whole system of sun and planets and satellites being connected and propelled by gears so that their relative motions were approximated. Ever since their first appearance, these devices have had and still have great value in teaching, the three-dimensional mechanism capable of simulating the motions of the heavenly bodies being incomparably more effective than flat pictures or pages of printed text.

In these mechanisms just described the observer is outside looking on—a condition that has been improved by placing the model of the solar system inside a spherical glass globe, upon the outside of which is represented the constellations with their principal stars and also the Milky Way—a transparent celestial sphere, certainly an improvement over the usual opaque celestial globe. Examples of this type are the "Astrophane," made by Mr. O. J. Russert, and the small Copernican planetarium just inside the entrance to the Fels Planetarium, made by Max Sendtner of Munich.

The next step in the evolution of the planetarium seems to be the model of the celestial sphere with the audience inside. This type has been developed in at least three different countries. In 1758 Roger Long, Lowndes Professor of Astronomy at Cambridge, built one at Pembroke College. The globe was eighteen feet in diameter and seated thirty persons. The only one of these that the writer has seen is in the Museum of the Chicago Academy of Sciences in Lincoln Park, built before 1913 by Dr. W. W. Atwood. It is known as the Atwood Celestial Sphere. It consists of a hollow metal sphere in which the most conspicuous stars of the sky are shown by lights outside of small, round holes through the sphere. The small audience is seated inside the globe, while the latter revolves as the real sky seems to do. In all of these devices heretofore described, so many astronomical bodies and so many movements and relations have been omitted that they are evidently inadequate.

Late in 1924 there appeared something new under the sun, an apparatus that shows every object in the sky that is visible to the unaided eye, and in a most realistic manner. The rising and setting of the sun, moon, and

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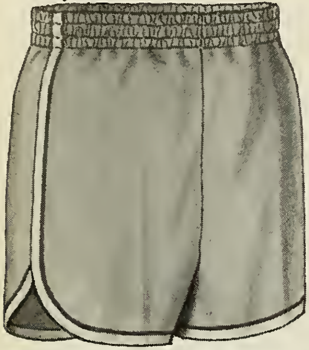

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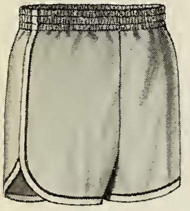

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stars are represented just as they occur in nature, due to the rotation of the earth on its axis. The moon goes through its phases. The planets are shown as wanderers among the stars, their direct eastward and their retrograde westward motions being represented with great accuracy. Even the precession of the equinoxes, together with the swinging of the celestial pole around a circle, which in the sky takes 26,000 years, is shown by this apparatus.

In this new projection planetarium everything is shown on the inside of a dome by projection of light from a central apparatus. The optimum size for this inverted bowl is from sixty-five to seventy-five feet in diameter. This hemispherical dome, which is white inside, becomes our artificial sky, and since there are no pillars or posts to intercept the light, the illusion of the depth of space is perfect. One feels that he has been suddenly transported outside under a clear night sky. The realistic appearance is beyond belief.

The projection apparatus, which is located on the floor in the center of the dome, is a bizarre-looking instrument some twelve feet high, resembling a huge dumb-bell with a long bar between the globular ends. The globes at either end of the instrument are for the projection of the fixed stars, one globe being for the northern and the other for the southern hemisphere of the sky. Each globe consists of sixteen stereopticons pointing in all directions with one central lamp. The lantern slides or diapositives are not square or rectangular, but are so shaped that their images fit together like the cells of a honey-comb, thus making a complete picture of the starry heavens without overlapping and without gaps.

The representation of the fixed stars, including the Milky Way, is a comparatively simple part of the performance of the instrument, and yet it is certainly the most impressive. It matters not whether the audience be made up of children or adults, or professional people or laymen, the emotional experience is always the same. When the light is gradually diminished, bringing on the darkness of night in the dome, and the stars are "turned on," the audience gasps audibly in surprise at the breath-taking beauty of it. No one is prepared for anything so realistic and so dramatic.

The names of the constellations may be shown on this artificial sky by means of a special set of projectors. The advantage of this over outdoor star-gazing in learning the constellations is obvious. With an optical pointer, or flashlight showing an arrow-shaped light, the lecturer can point out any star, planet, or other body in the sky. It is evident that an ordinary fish-pole pointer, even with a tiny light at the tip, would be precluded by the large size of the dome.

In the bar of the dumb-bell between the globular assemblages of stereopticons showing the stars, are seven special projectors, one for each of the five planets visible to the unaided eye from the earth and one each for the sun and moon.

The whole apparatus has several different speeds, all of which are many times faster than the real motions. This makes it possible to condense a long astronomical story into a short time, and with increase rather than loss of drama, so that a child or a grown-up, who has not stopped learning, can get a clear undertstanding in a few minutes of the seemingly intricate though actually simple workings of the heavenly bodies.

With the projection planetarium, one can change his latitude at will. He can go to the Land of the Midnight Sun or to the North Pole, and observe the apparent movements of the sun and moon and stars there; or he can go to the equator, or to southern latitudes and see the Magellanic Clouds, the nearest fixed star visible to the unaided eye, and the romantic Southern Cross.

With the projection planetarium one can go backward or forward in time. He can set the instrument back say 2000 years and note with accuracy the configuration of the planets among the stars at that time; or he can set it back 5000 years, say to 3000 B. C. when Alpha Draconis, the brightest star in the constellation, The Dragon, was our North Star; or he can set it forward say 12,000 years when Vega will be our North Star, and the Southern Cross will be visible from the latitude of New York.

Dr. Philip Fox, formerly professor of astronomy and director of the Dearborn Observatory at Northwestern University, brought the first Projection Planetarium to America and introduced it to our people. Thanks to the generosity of Mr. Max Adler, it has been established in Chicago in conjunction with the best astronomical museum in America, and Doctor Fox is director.

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Made possible by the generosity of Mr. Samuel Fels, the second American projection planetarium has been installed in the Franklin Institute in Philadelphia, where it was opened last November. Mr. James Stokley, formerly of Science Service, is director.

The third American projection planetarium is soon to be installed in a building nearing completion in Griffith Park, Los Angeles. It now seems quite certain that New York City will have the fourth American projection planetarium.

The educational value of the projection planetarium is now widely recognized.

With Dr. Oskar von Miller, director emeritus of the Deutsches Museum in Munich, and with Mr. Waldemar Kaempffert, science editor of the *New York Times* and former director of the Museum of Science and Industry in Chicago, we believe that a combination of the Projection Planetarium and a large Copernican Planetarium, similar to the one in the Deutsches Museum, will make an ideal teaching unit, and in accordance with this belief we have planned to install both types of planetarium in our new building.

In the planetarium building, besides the projection planetarium, which is obviously the chief attraction, and the large Copernican planetarium on the floor below, which will be immensely valuable in bridging the conception of the apparent and real motions of the heavenly bodies, there will be many accessory exhibits planned to make the whole astronomical hall a complete and well balanced institution for stirring the imagination and enlightening the mind.

Among these will be the great collection of meteorites belonging to the American Museum. This collection consists of several thousand specimens, representing a few hundred falls. Among them are three brought from Cape York, Greenland, by Peary —one of these, the Ahnighito, weighing 36½ tons, being the largest meteorite in any museum in the world. There is also the famous Willamette meteorite, weighing 15½ tons, which fell near Portland, Oregon, and which has the unusual deep pits developed after its fall. Several specimens, one weighing a few hundred pounds, have come from the vicinity of Meteor Crater in Arizona.

In short, this is one of the most spectacular collections of meteorites in the world, and it will be installed on the main floor of the planetarium building just outside the Copernican planetarium. Up to the time when Kirchhoff made the principles of spectroscopy available, meteorites furnished our only direct and positive evidence of the constitution of any of the heavenly bodies outside of the earth.

Large transparencies made from the finest astronomical photographs in the world will be shown on the walls of the ambulatory around the Projection planetarium dome on the second floor, and on the walls of the first floor around the Copernican planetarium.

Sundials of several types, dial-rings, astrolabes, compasses, hour-glasses, replicas of Galileo's telescopes, and various instruments of historic interest in astronomy will be shown in well lighted cases.

A coelostat, a spectroscope, and a spectroheliocope, all functioning on clear days, so that the results can be observed by visitors, are included in the plans.

A Ptolemic planetarium, three or four feet in diameter, illustrating the old earth-centered theory of astronomy, epicycles and all, enclosed in a spherical glass globe, with a crank that may be turned by visitors, is included.

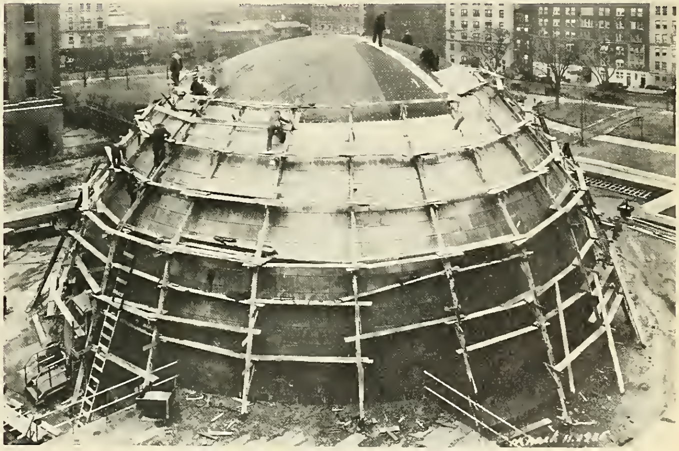
A Foucault pendulum to show the rotation of the earth on its axis, and a vortex of water to illustrate the same phenomenon are contemplated.

The modern trend in the interest in astronomy will be shown, not only by transparencies from some of the newer photographs of spiral nebulae or galaxies, but also by a model of a galaxy, and a model to show something of what is known about the distribution of the nearer stars in our own Milky Way Galaxy.

All of the astronomical paintings by Mr. Howard Russell Butler, which are now shown in the Pro-Astronomic Hall, as Professor Henry Fairfield Osborn affectionately referred to it, will be reinstalled in the new planetarium building. These include the famous triptych of eclipses (1918, 1923, and 1925), and we hope to add Mr. Butler's fourth picture of a total eclipse of the sun, that of 1932. These are, without much doubt, the finest oil paintings of eclipses ever made. Perhaps as high praise could be given to Mr. Butler's two paintings of Mars, as well as to his other paintings in the hall.

On the outer wall surrounding the Copernican planetarium, on the first floor, there is planned a zonal oil painting representing the zodiac, that belt in the heavens in which the planets are found. This painting will show the mythological figures of the signs of the zodiac and the principal stars of the zodiacal constellations.

To greet the eyes of visitors as they first enter the building, there is under consideration a large decorative painting in oil, in three panels, illustrating American Indian astronomical mythology. Although primarily from the Blackfeet, the myths selected are those of rather wide distribution with little variation among the various tribes of North America. The left panel shows the Northern Lights of Aurora Borealis in the form of an arch in all the delicate colors, in which may be dimly seen the figures of the White Men of the North dancing around their campfires. The central panel shows the sun-



*Planetarium dome under construction*

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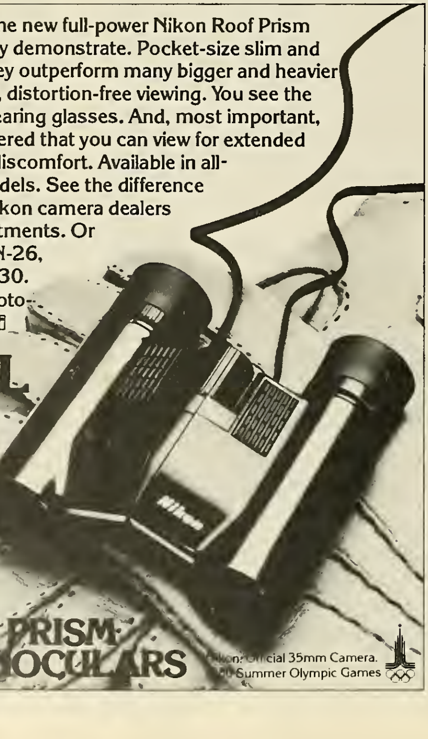

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god on a brilliant yellow background, the moon-goddess on a paler background, while in the upper right may be seen the Pleiades as conceived by the Indians, and in the upper left the Big Dipper and the North Star. These corner representations, with the Milky Way or Sky Trail between them, are shown in silver on a background of deep blue. In the lower left corner is represented the story of the creation of the earth by the Old Man. On the right panel is seen a symbolic Thunder-bird in the clouds with the conventionalized zigzag lightning striking from the cloud to the earth.

The planetarium building has been made possible by a loan from the Reconstruction Finance Corporation, while the instruments, both the projection planetarium and the Copernican planetarium, are the gift of Mr. Charles Hayden of New York City, for whose generosity a multitude of persons will be sincerely grateful.

Many of Dr. Fisher's plans had been realized by the time the Hayden Planetarium opened to the public October 3, 1935. The projection and Copernican planetariums were in place, wall transparencies and Butler paintings were on display, meteorites lined the walls, and the American Indian allegorical painting greeted the visitor at the entrance. But much has changed in the forty-five years the Planetarium has been serving the public.

The Ahnighito meteorite, which was brought from Cape York, Greenland, by Admiral Peary at the turn of the century, was displayed in the Planetarium from its beginning and was then mounted on a Toledo scale in the 1950s. In September 1979 it was removed to the American Museum's Arthur Ross Hall of Meteorites (scheduled to open in the fall of 1980). The zodiac mural in the Copernican Room has been covered by twenty-two projection screens in what is now called the Guggenheim Space Theater. The Butler eclipse triptych is behind a wall in IBM's Astronomia, and another wall covers the allegorical painting. No Foucault Pendulum was ever hung here, but a collection of sundials and old instruments, the bequest of Miss Susan D. Bliss, is still displayed in lighted wall cases.

A new wing added in 1973, courtesy of the Richard S. Perkin Foundation, houses our research library, as well as the Hall of the Sun, which was funded by the Billy Rose Foundation. The Sky Shows feature our third Zeiss projection planetarium: the first was replaced in 1960; the second in 1969, helped by the Hayden Foundation.

And we are approaching an attendance figure of 23 million visitors.

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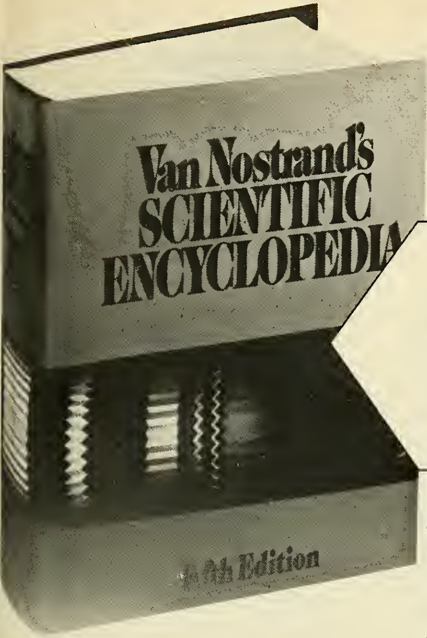
*K. L. Franklin*
*American Museum–Hayden Planetarium*



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*JANUARY/FEBRUARY 1926*

# THE ORDEAL OF GETTING CIVILIZED

Troubles of an Indian Treading the White Man's Path

BY GILBERT L. WILSON

THE old Indian was wending his way upward to his cabin, but stopped halfway up the hill. He was too far away for us to see his features, as he stood gazing earnestly into the evening shadows where they fell on the rolling Missouri; then he turned again toward his cabin.

The young reservation schoolmaster laughed.

"Old Wolf-eye," he said, "I guess he is thinking of other days. He often comes out in the evening and stands gazing at the river. He finds it hard to live like a white man, but he is making a plucky try at it."

"Making any progress?" I asked.

"More than I would make if I were an old buck like him. He's been out in twelve war parties and lifted a half dozen scalps. He walks the white man's way now —has a small trading store beside his cabin; and with a few cattle and horses, and a potato field, and corn, he manages to get out a pretty fair living."

"Does he know English?"

"No, can't speak it anyway. He attended the reservation school for a time, after he was thirty years old, and learned to figure and spell easy words, so he can keep accounts in his trading store; but he has to have an interpreter if a white man comes in. Old Wolf-eye isn't a bad fellow, honest as pure gold."

"Good qualities," I said.

"They certainly are; and Wolf-eye isn't above learning yet, if he is old. Last winter he let his squaw go down to the woods every Monday and cut the week's wood. In the evening the old buck went down with his pony and sledge and hauled the wood home. I told him that wasn't a white man's way; that our women didn't cut the wood; men did that. He was much surprised. 'Indian women always chopped wood in old times,' he said. 'I thought white women did.' The next week old Wolf-eye went to the woods with his ax, and in the evening his squaw brought down his horse and sledge. I guess Wolf-eye isn't as good an ax man as his squaw, for his load was smaller." And the schoolmaster chuckled.

I had wondered what would be the trials of an Indian getting adjusted to civilized life and it struck me that here I had a real find, a native of the old school, who could make clear to me the difficulties a barbarian must experience in treading the white man's path. I determined to seek out Wolf-eye.

The evening of the next day found me with my interpreter, Wolf-eye's nephew, in the old Indian's cabin. The sickly glow of a kerosene lamp half-lighted the room. Wolf-eye sat rather back in the shadows, but his face was toward the light and showed heavy but regular features, with full lips, wide cheek bones, and kindly eyes. He wore a calico shirt outside his overalls; on his feet were moccasins. He was smoking a long-stemmed pipe of redstone. Evidently he was expecting us. A comb lay on the table and his hair, untinged by gray, was newly kempt. Indian-like, Wolf-eye let me begin the conversation.

"You Indians don't show your age," I began diplomatically. "I think you are older than I, but your hair is black as a raven; mine is quite gray."

His answer rather startled me.

"I wish my hair was gray. Then I would be a white man."

"But why would you want to be a white man?"

"Because then I could learn more about this world. I can speak very little English; and there are not more than 500 people to whom I can speak in my own language. What can I learn of them? I know a big war has just ended in Europe. What caused that war? I want to *know* things." The interpreter's English was broken, but I have put his words into intelligible idiom.

"But Wolf-eye," I said, "at least you can live like a white man even if you are not white."

"That is not an easy path for an Indian to walk. Indian ways are not white man's ways, and one cannot refuse to keep to the customs of his tribe. In olden days, we Indians held our foods almost in common. When one family ate, all ate. When one family starved, all were starving. We could not do otherwise. There were few families in the tribe which had not more than once been saved from starvation by food stores of others, especially in winter.

"We do not live so close to starvation now, but we find it hard to forget our old customs. A young couple, just home from the white man's school, are eager to raise wheat and build a good house. In the fall, they gather in their crops and store up potatoes, beans, and dried meat for winter. Then their relatives come to visit them, and stay until all their food stores are gone. I do not think white people do that.

"It is the same if we try to raise stock. Our agent tells us that we ought to raise hogs. My son bought a pig to raise. He built a pen for that pig, and fed it much corn; and he subscribed one dollar for an agricultural paper, to learn how to raise that pig. In the paper he read that he should let the pig out every afternoon for fresh air. So my son bought an alarm clock for two dollars, and set the alarm every day for four o'clock, so he would re-

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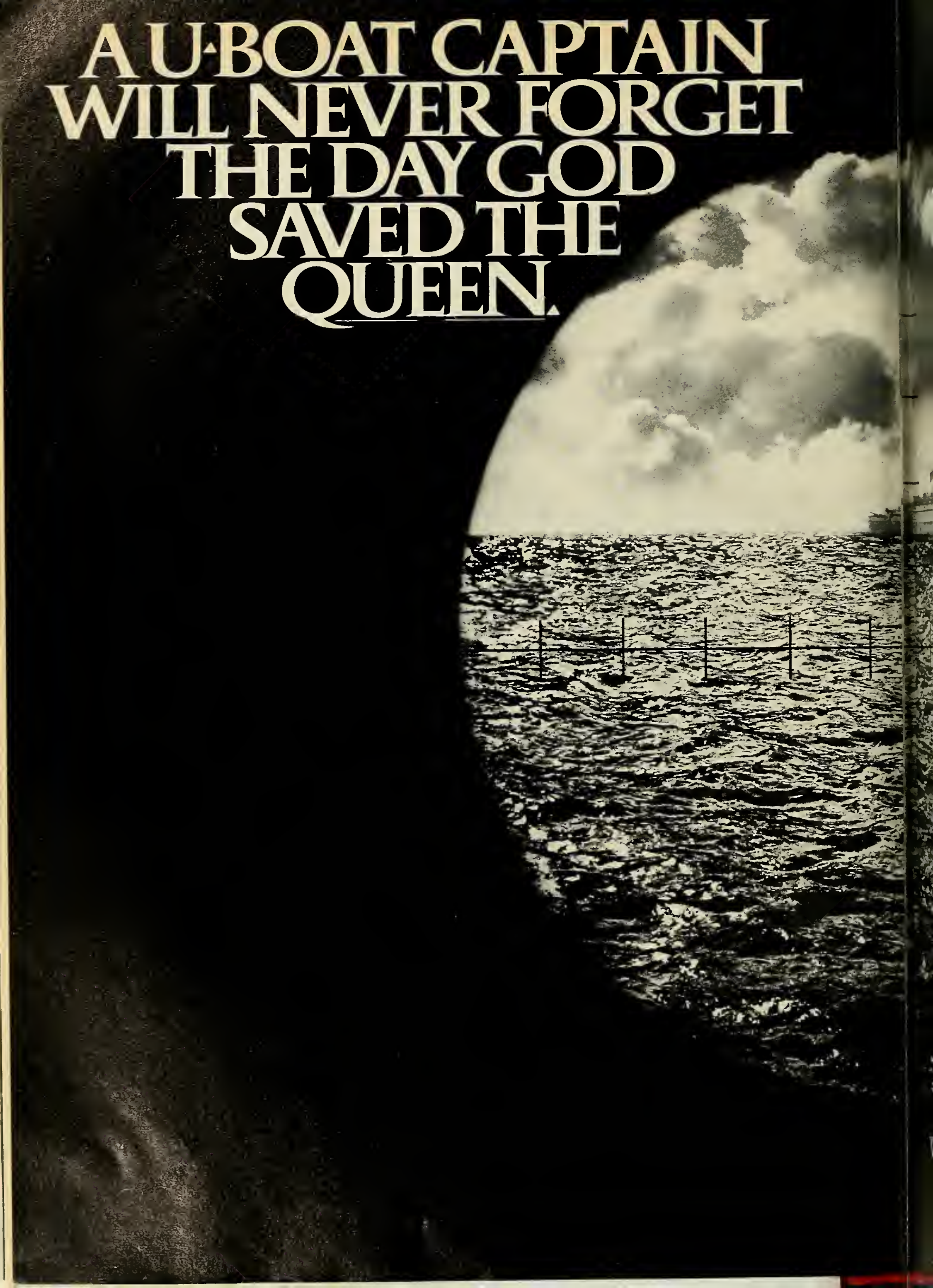
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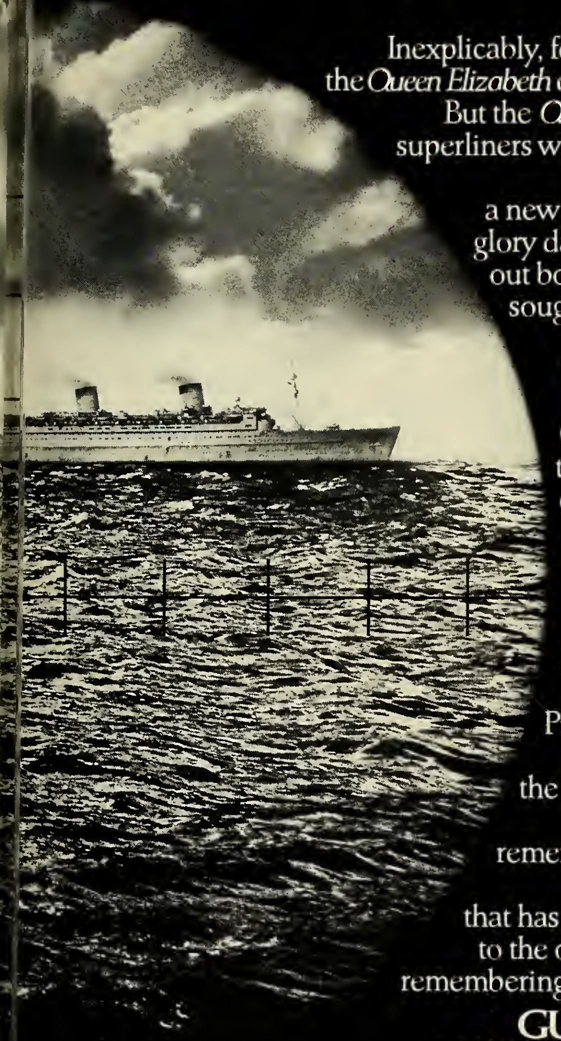

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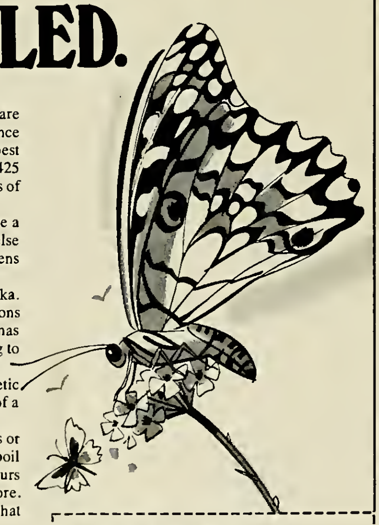

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member to let out his pig. The pig grew big and fat, and the bigger it grew the more corn it ate. That pig never seemed to get enough corn. In October my son butchered that pig. Then all the families of his relatives came to see that dead pig, and to every family my son gave a big piece of meat. In four days all the pig was eaten. My son says it does not pay to raise pigs."

"But this reservation has fine grazing lands," I said. "Why don't you keep milch cows?"

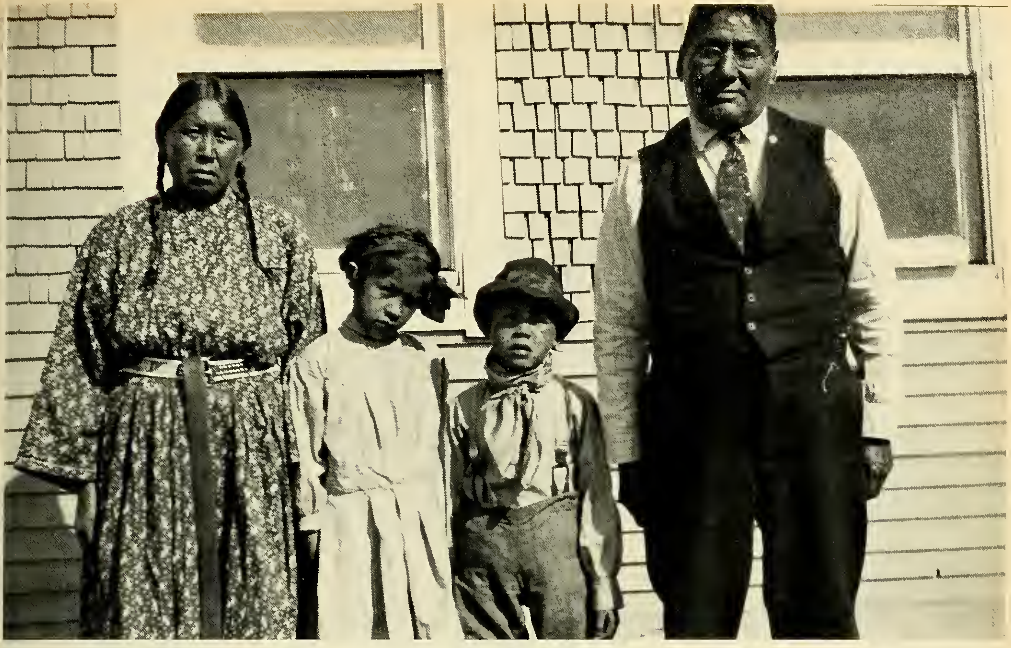
"We tried to keep milch cows," answered Wolf-eye, "for we liked the milk. But none of our older Indians can read or speak English. The Government has allotted us farms and tells the Indians they must live on their farms. But these farms are far apart. The 500 Indians of my small tribe are scattered for fifty miles along the Missouri River. They have no books to read, no magazines to amuse them. An Indian family becomes lonesome and goes to visit friends; maybe they cross the Missouri in a flat boat, and are gone two or three weeks. When they come home again they find their cows dry; or the cows are wild, and kick if the Indians try to milk them. Also the coyotes have stolen the Indian's chickens. One cannot keep a strong heart when things are like that."

"But your young men are educated in our schools. If they are ambitious, they can join white communities and live like white men."

"That is hard to ask of them. A young man's heart yearns for his own people. In olden times, a young man was ambitious. He was eager to be a warrior, not that he liked to fight, but if he struck an enemy, everyone praised him, girls smiled at him, and he could marry any one he wanted. White men are ambitious to make money, so that others will think well of them, and they can marry into good families. But we Indians cannot get rich on this reservation, where all our relatives visit us and eat our food. There is now nothing to make us ambitious."

"But if your young men are educated and know English, why cannot they compete with whites, and get rich as white men do?"

"That is not easily done. Our reservation schools are not good, and an Indian lad is not equipped as a white boy is equipped. Then, even if a young Indian has a strong heart, there is not much he can do on this reservation and his relatives often try to keep him back in the Indian ways."



*Wolf-eye and family, 1913*

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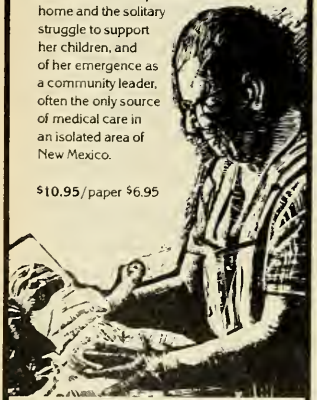

La Partera

The Story of a Midwife

by Fran Leeper Buss

Jesusita Aragon was fourteen when she earned the title "La Partera," midwife. This is her story, told in her own words, of her training as a midwife, her forced departure from home and the solitary struggle to support her children, and of her emergence as a community leader, often the only source of medical care in an isolated area of New Mexico.

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The University of Michigan Press

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"Cannot many of your young men find employment with white people?"

"Some of them do, but white men often refuse to employ Indians. Even if trained to some trade, an Indian raised on our reservation cannot know the thousand-and-one little things that will make him at home in white society and which are such a help to one's work."

"But white men usually treat Indians kindly, do they not?" I asked. "Americans admire the Indians. Many books are written about Indians and their customs."

Wolf-eye answered with feeling, but he spoke calmly.

"For twenty years I have tried hard to learn white men's ways. In all that time I have met but three white men who treated me like a brother, Mr. Hall, the missionary, an agency clerk, and a man who came to us from the American Museum of Natural History. We Indians are proud. It hurts our hearts when white men tell us we are greasy and dirty. We do not like to have them say, 'You are just like dogs!' We Indians know very well how we live, and that our old customs do not fit into the life our young people must learn to live. In old days, every young man went each morning for a bath in the Missouri; in winter he cut a hole in the ice, and after his bath, rubbed himself with white clay. We lived then in Like-a-fishhook Village, right on the river. Now our families are, many of them, two or three miles from the river, and we have no baths in our cabins.

"Our clothes are not neat and clean, like white men's clothes. In olden days, we dressed in skins, which we could clean with white clay. Now our clothes are of cloth, and we do not know how to care for them. Many of our women own washtubs, and know how to use soap; but it is hard for them to heat water in our cold winters. Our cabins are small; our women cannot take their tubs out of doors in the biting wind, when the ice is four feet thick on the Missouri; and if they wash the clothes in the cabin, the air gets full of steam while the water that splashes on the floor freezes. Then the door is opened to let out the steam and the room gets cold; so we build a hot fire in the stove, until we have to open the door again, to cool the cabin. Our children thus catch cold, and have lung sickness."

"But you have more to eat now than you had when you lived by hunting, have you not?" I asked.

"Yes, but we do not know how to prepare many of our new foods. In old days, when a buffalo was killed, our women knew how to cook every part. But our women cannot make things like rice, potatoes, wheat, and oats, into good-tasting foods. And this I think very bad for sick people. An Indian woman's baby gets sick. The reservation doctor is maybe thirty miles away. That Indian woman gets scared. She does not know what to do. She remembers that when she feels tired, she drinks coffee, and it makes her feel good. So she makes a big pot of coffee, and gives it to that baby. Maybe that is why so many babies die on this reservation."

"But you have many things, now, that you did not have then. Do you not live more comfortably?"

"In many ways, yes. We have iron axes, and iron hoes and guns. Iron axes make the work of our women easier. When I was a boy, we still lived in earthlodges, which our women built. My grandfather told me that it was hard to cut posts with stone axes, and split puncheons with horn wedges. Our iron hoes are better than our hoes of bone; and we can cultivate more corn now that we have plows.

"But I am not sure that gunpowder has been a blessing. For a time that made it easier to hunt game, but the buffalo herds were soon killed off. Then, in olden days, when we fought with arrows, not so many men were killed. After the Sioux got guns, they could come opposite our village, and shoot across the Missouri at our women as they went down to get water. The Sioux could not have done that with arrows."

"I am sure horses are useful to the Indians," I said, "and you have other live stock, also."

"Yes, we have cattle; some families raise pigs, and not a few have chickens. But we have other live things from white people that we do not like. We have rats and a new kind of mice. We did have lice in old times, but we never had flat bugs that now get into our beds."

"But I hear that the Indians are having better health now that they send more often for the reservation doctor when they are sick."

"That is true. I think he understands many white men's diseases better than our medicine men do. Then, too, he tells us that in the white man's road we are now trying to travel, there are many things that make us have dis-

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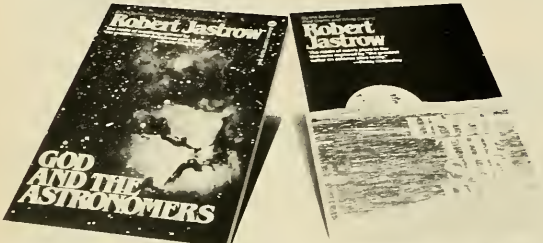

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eases, that we did not know in our old life. He says we will get lung sickness if our cabins are not clean. My wife sweeps my cabin every day and I whitewash the outside and the inside twice a year. If my child takes sick, I send for the reservation doctor right away. But my father was a medicine man who said sickness comes from evil spirits. If the doctor does not come at once to my sick child, I sometimes sing one of my father's sacred medicine songs. I cannot always wait till the doctor comes. Once a man from a museum wanted to buy my father's medicines. I was afraid to sell them, because I knew the wonderful things those medicines had done. I worship the one, true God now, and I know it is wrong to worship my father's medicines, and I never do worship them. Still, I know the magic cures they have done, and I was afraid to sell them to the museum until one night I had a dream from my father's spirit that they would be put into a big house built of stone, in New York, where they would rest forever and white people could see them. I thought, too, that it was perhaps best to sell them away from the reservation. I am a Christian now and if those medicines are in New York the spirits that may be in them will not get angry at me because I do not worship them. It is very hard for me to be a Christian because I cannot read the Bible much in English, and so I cannot know all of God's commandments. Then, too, I see Christians do things which the missionary tells me are wrong when I do them. I do not understand it!"

"Your children will understand better, perhaps, because they are now being taught the Christian way in the mission schools."

"It is true; but they are learning many things that I cannot believe. The missionary teacher tells my son that the earth is round like a ball. That seems foolish to me. I have stood on the top of one of the Rocky Mountains, and the earth looked flat, just as it does here on the prairie. The teacher also says it is wicked to make war, and our Indian warriors did wrong in old days when they went out to fight other tribes. Why then do white men make war? In that big war in Europe, the Government took many young Indians from this reservation to be soldiers, to fight the Germans. Why don't white men leave off making war?"

And come to think about it, why *do* white men make war?

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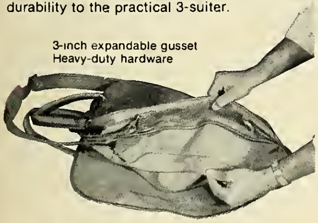
Each time you find yourself marking time by a carousel and experiencing a twinge of anxiety when your suitcases are delayed or lost, our Carry-All Wardrobe increases in value.

The Camelot Carry-All Wardrobe is entirely new — in design, styling and concept. Final production samples were four months in the making. Afterwards, our carry-on bag was "people-tested" by a variety of executives. Remarks like "convenient . . . comfortable . . . easy . . . peace of mind . . ." followed business trips to the Orient and throughout the states. We knew we had a winner. Especially when everyone asked, "How can you offer it so inexpensively?"

Luggage often follows a manufacturer, distributor, salesmen route with quite a few markups and commissions built in. Ours was built for us and comes directly from the factory. It could easily sell for $60 to $80. But, we've priced it to be an incomparable value.

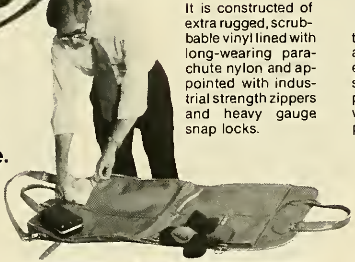
### BEAUTIFULLY STYLED

The Carry-All is finished in an exquisitely plush, deep brown, leather-grained polyurethane leather. Industrial strength zipper closures are handsome appointments that add long wear durability to the practical 3-suiter.



### A BAG FOR ALL REASONS

The Camelot Carry-All is a 3-suit, expandable garment bag with ample room for shoes, shirts, toiletries and anything else you might need for an overnight or week-long trip.



It is constructed of extra rugged, scrubbable vinyl lined with long-wearing parachute nylon and appointed with industrial strength zippers and heavy gauge snap locks.

### COMPARE ITS HOLDING POWER

Its overall size is approximately 38" tall by 22½" wide by 8½" deep. Aside from the 3-suit garment bag, there's a **suitcase compartment** with a built-in shoe bag and a wrap-around zipper that opens wide to accommodate a wealth of apparel.

There's a second zippered pocket that's 17" tall by 22" wide by 5½" deep with a 1" gusset and a zippered closure that can handle files, reports, extra shirts, etc.

If that's still not enough, the Carry-All has still another smaller zippered pocket that's perfect for jewelry, etc. And there's also a special tie rack that easily holds several ties neatly out of the way.

Best of all, the Carry-All is comfortably compact. It will hang like a carpack or zip up like a suitcase. When folded, it measures just 17" tall. You can carry it as a conventional case by its reinforced, cushioned handles or wear it on your shoulder. The adjustable shoulder strap is included. When folded, the Carry-All rests on five rubber feet.

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# THE NEW PLANET

## A DRAMATIC DISCOVERY

A Brief History of the Planets Known to Science, and the Most Recent Triumph of Scientific Investigation

BY CLYDE FISHER

*Then felt I like some watcher of the skies*
*When a new planet swims into his ken.*
—JOHN KEATS

THE finding of a new major planet had occurred but twice since the dawn of history—so one can understand the excitement occasioned during the early weeks of 1930 by the picking up of an ultra-Neptunian world. Predicted by the late Percival Lowell, and first "sighted" as a faint spot on a photographic plate, the discovery of the new planet was completely established by Director V. M. Slipher and the astronomers of his staff at the Lowell Observatory. A brief survey of the earth and neighboring worlds already known possibly will help us to appreciate this recent dramatic event, this triumph of scientific investigation.

To the ancients five planets were known, namely, Mercury, Venus, Mars, Jupiter, and Saturn. They, of course, did not know that the earth belonged to this group. In fact, for many centuries preceding the adoption of the Copernican theory of astronomy, it was thought that the earth was the center of the universe.

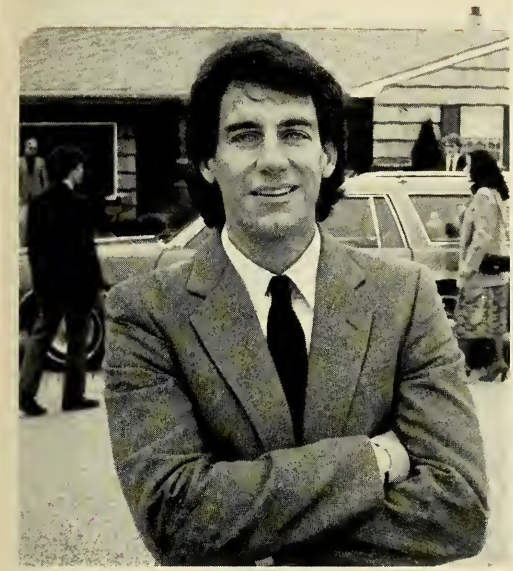
When we consider the matter, we realize that this geocentric notion was a natural conclusion to be drawn from observation. The sun was seen to rise in the east, to pass over the sky, and to set in the west, and the next morning it was again seen to rise in the east. It surely seemed that the sun went round the earth. The moon was seen to rise in the east, to pass over the sky and to set in the west, and the next day it was observed to rise again in the east. It also seemed that the moon went round the earth. (We now know the moon does go round the earth about once a month, but this motion does not account for its daily rising and setting.) The stars were also observed to rise in the east, to pass over the sky, and to set in the west, and the next evening the same ones were seen to rise in the east again. Thus it seemed that all the bodies in the sky revolved around the earth, and the earth seemed to be the center of the universe.

The great Ptolemy believed the earth to be the center of our family of planets, and his system was orthodox astronomy for fourteen hundred years. However, there came a time when this theory received a rude jolt. About the middle of the Sixteenth Century there was published a book by the great Polish astronomer, Copernicus, setting forth the theory that the sun is the center of our system of planets, and that the rising and setting of the various heavenly bodies is only an apparent motion due to the rotation of the earth on its axis.

Mercury is the innermost of the known planets, according to the Copernican system of astronomy. Although it is 36,000,000 miles from the sun, it is still so close to that huge incandescent body that it is generally overwhelmed by the light of the latter. It can be seen only when at or near its greatest eastern or western elongation, that is, when it makes the greatest angle with the sun. It is so close to the sun that it goes round that body in eighty-eight of our days. We are not quite sure whether Mercury has an atmosphere, but very probably not. It is believed that it keeps the same side toward the sun all the time, and that the temperature of that side is high enough to melt lead. Mercury, like all the rest of the planets, shines only by reflected sunlight, and since its orbit is inside that of the earth it goes through phases as our moon does, and for the same reason. If Mercury had any satellites, it is believed they would have been discovered at one of the recent transits of the planet across the sun.

Venus is the second planet in order from the sun, and it makes the circuit around that central body in 225 of our days. Venus comes closer to the earth than any other of the major planets. It comes nearly ten millions of miles closer than Mars. When at or near its closest position to the earth, Venus is the brightest object in the sky except the sun and moon. There are only two known planets that can go through the crescent phase—one is Mercury and the other is Venus. The first person to see Venus as a waxing and waning crescent was Galileo. If Venus had any satellites, it is believed they would have been discovered at the last transit of Venus across the sun. Only two planets can come between us and the sun, namely, Mercury and Venus. The last transit of Venus occurred in 1882, the next will be in the year 2004. Very little is known about the surface of Venus because of the dense, opaque atmosphere which surrounds the planet. This member of the solar system may have been given the feminine name because of its great beauty as a morning or evening star. When Venus is near the earth and the telescope reveals it as a thin crescent, resembling the new moon, the observer is no less charmed by the surprising beauty.

The earth is the third planet from the sun, although the ancients did not realize that it was one of the group of wanderers through the sky, five of which they knew besides. On our imaginary journey from the sun, the earth is the first planet that is known to have a satellite, and this satellite, which we call the moon, is the only body in the sky which goes round the earth. The moon



# One of these men drives himself to work, drives himself home and drives up his cost of living.

He doesn't see it that way. He's been driving himself to the office every day for several years now. He actually enjoys the ride.

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The man on the left has decided to conserve and save. When the gasoline shortage began, he and some neighbors started carpooling to work. So together they consume less gas. That cuts expenses right there. What's more, because each of them drives fewer miles, they save money on their auto insurance as well.

As a major group of property and casualty insurance companies, we're doing our best to help you keep your insurance rates affordable. That's why most auto insurers are offering discounts to those individuals who reduce the total number of miles or times they drive to work.

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■ Working through the Insurance Institute for Highway Safety to make cars and roads safer.

■ Investigating injury and repair claims more thoroughly.

**Here's what you can do:**

■ Cut down on your driving by carpooling or by using public transportation.

■ Use your auto seat belt and shoulder harness.

■ Talk to your insurance agent or company about ways to lower the cost of your auto insurance coverage.

■ Lock your car. Don't invite trouble.

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YOU CAN HELP SAVE THE SNOW LEOPARD

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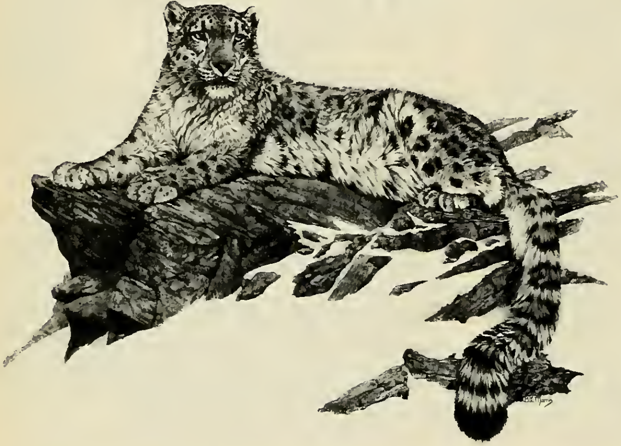

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The SNOW LEOPARD is almost extinct and it is protected by law in Pakistan. The export of a Snow Leopard skin is illegal and will jeopardize the survival of this beautiful animal.

Time is running out for the magnificent Snow Leopard. Although it is protected by law, native poachers, using snares, guns, and poisoned spears, are exterminating this high mountain cat for its luxurious pelt. Only a change of attitude among local peoples toward this unique animal can save the Snow Leopard from extinction.

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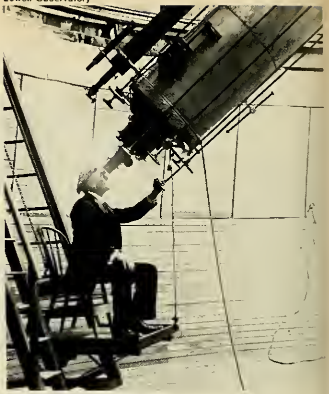
Lowell Observatory



*Percival Lowell*

completes this circuit in about four weeks, as can easily be observed.

The mountains and craters on the moon were first seen by Galileo, through the first astronomical telescope ever made. These features of the moon's surface may be observed best at first quarter or on the two nights thereafter, or at the equivalent time about last quarter. At full moon there are no shadows to bring out the relief of the moon's surface. There are several ranges of mountains on the moon, the lunar Apennines being the most extensive. This is a slightly curved range four or five hundred miles long, and rivaling the Andes of South America in height.

The so-called seas, so named by the ancients, are now known to be plains, for there is no water on the moon. A large part of the surface of the moon is abundantly covered by craters of all sizes up to one hundred miles in diameter, named for astronomers, philosophers, and others. The Crater Copernicus is fifty-six miles in diameter while the Crater Tycho has a diameter of eighty miles. Two theories for the formation of these craters have been advanced, namely, the volcanic theory and the impact theory. According to the former they are thought to be due to volcanic action in a manner similar to the formation of volcanic craters on the earth. According to the latter they are supposed to have been caused by the falling of meteorites or planetesimals into the moon. There is one crater on the earth which seems to give weight to this theory, and that is, Meteor Crater in Arizona. Aeons ago there may have been many more on the earth, but if so, the agencies of erosion would probably have removed

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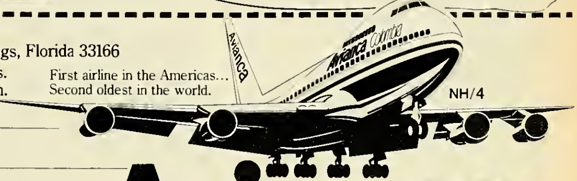

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them. Since there is neither atmosphere nor water on the moon, these craters, regardless of their origin, have probably changed little or none. Their large size, whatever may have been their origin, is probably correlated with the lesser force of gravity on the moon than on the earth. A man weighing 150 pounds on the earth would weigh about twenty-five pounds on the moon. Therefore volcanic matter, or matter thrown by the impact of a body falling into the moon, would be thrown six times as far as on the earth. The moon with its "seas" and mountains and craters is a magnificent object through even a small telescope. One's first sight of the moon through the telescope can never be forgotten.

Mars is the fourth planet from the sun, and next outside the earth. It is the one that appeals most to the popular fancy, on account of the perennial question of whether there is life on this neighboring world. Although Mars does not come as close to the earth as Venus, we are able by means of the telescope to make out much more about its surface, due partly to the greater transparency of the atmosphere of the former. Mars presents a ruddy surface relieved by darker areas, polar caps, and the much-discussed "canals."

The polar caps can be seen with a small telescope, and they have been observed to change in size according to the season, just as the polar caps of the earth do.

The line-like markings on the surface of Mars, which were first designated "canals" by Schiaparelli, have occasioned much discussion. Whether they are waterways bordered by vegetation, thus making them wide enough to be seen through our larger telescopes, is still an unanswered question.

The axis of Mars is inclined almost the same as that of the earth; hence, the planet must have similar seasonal changes, since there is atmosphere and water on the planet, but on account of the longer time required for revolution around the sun (687 days), the seasons must be nearly twice as long as those on the earth. A Martian day is 24 hours and 37+ minutes in length.

Since the temperature of the surface of Mars has been measured and found not too low to preclude the possibility of life, and since there is air with oxygen, and since there is water as vapor in the clouds, which however are rare, and solid in the polar caps, and probably liquid—these conditions consid-

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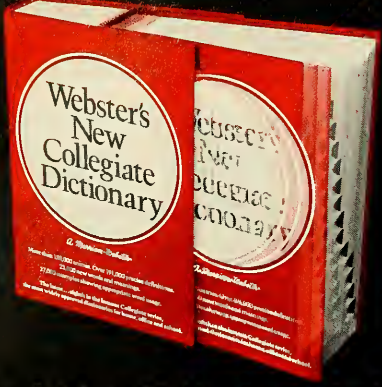

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ered together with the motions of the planet—it seems to be the consensus of opinion among astronomers that there is life on Mars.

Jupiter is the next major planet outside of Mars. It is the largest of the planets, and requires nearly twelve years to go round the sun. It rotates on its axis in a little less than ten hours. It has four large satellites and at least five small ones. The four large moons were discovered in 1610 by Galileo. The observed variations in the times of the eclipses of Io (one of the Galilean satellites) with the varying distance of the earth from Jupiter led Roemer in 1675 to make the first determination of the velocity of light. Jupiter presents only an outer surface of cloud, and definite bands in these surface clouds can be seen easily through a small telescope. The surface of Jupiter is cold, the thermocouple indicating approximately 100 degrees below zero.

Saturn, the sixth planet, is considered by some to be the most beautiful telescopic object in the sky, due to the rings, which were formerly referred to as "the fiery rings" of Saturn. Now it is known that these rings are composed of myriads of small solid bodies or moons, and that they are cold. Besides the rings, Saturn has eight relatively large satellites and one or two small ones. Saturn is so far from the sun that it takes nearly thirty years to go round the sun.

Uranus, the seventh planet from the sun, was discovered in 1781 by Sir William Herschel. He saw it as a hazy disc, slowly moving among the stars, and at first thought it to be a comet, and announced it as such to the Royal Society. Very soon, however, its planetary character was established, and Herschel named it Georgium Sidus in honor of the King of England. The name, "The Georgian," was used in the *Nautical Almanac* up to 1850, but it was disliked outside of England. Lalande proposed the name, "Herschel," which is found in some of the old books. Bode proposed the name Uranus. The planet has a revolution period of 84 years. Uranus has four satellites, the orbits of which are inclined to the plane of the planet's orbit and to the ecliptic more than 90 degrees, so that the motion of the satellites is really retrograde.

Neptune, the eighth major planet in order from the sun, was discovered in 1846, after its elements had been computed independently by Adams and Leverrier, the story of its discovery

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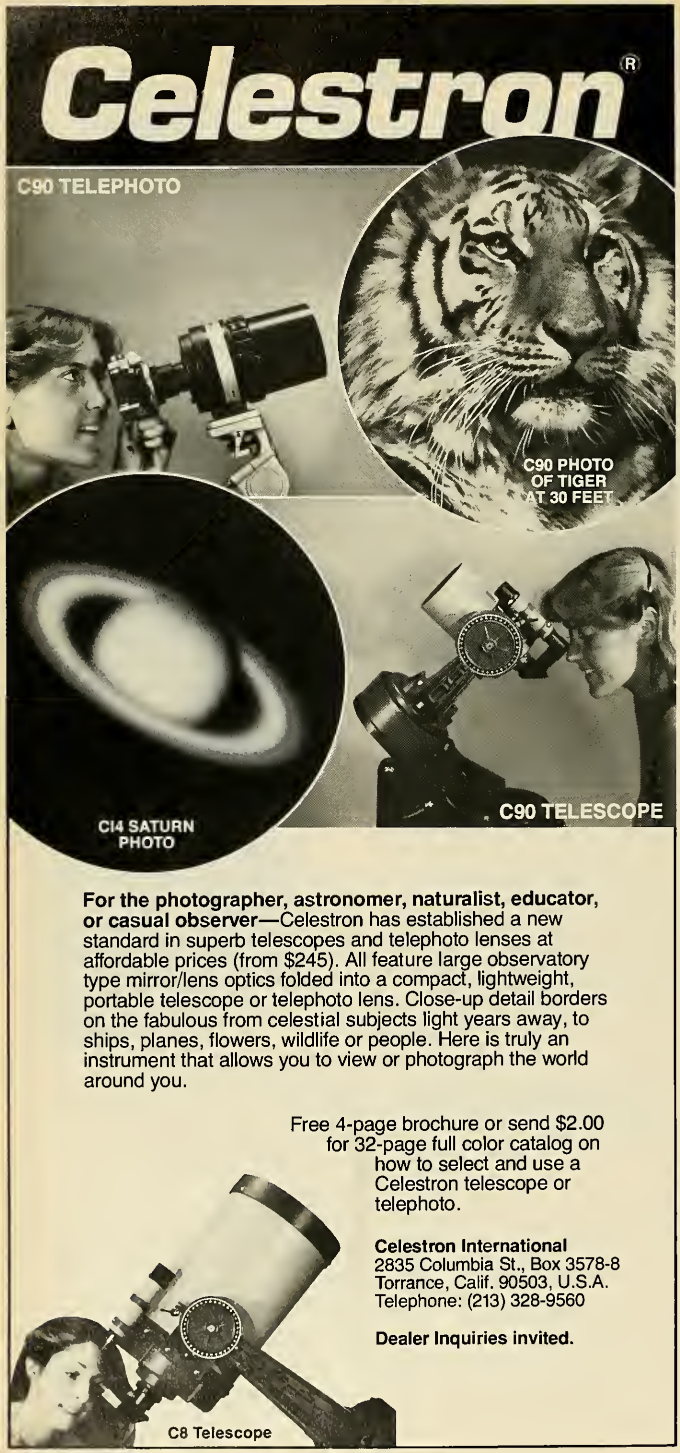

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probably being the most dramatic event in the history of astronomy up to that time. The planet was found almost exactly where these two astronomers had calculated that it should be, from irregularities in the orbit of Uranus. Neptune requires nearly 165 years to complete one revolution around the sun. It has gone only about half way around the sun since its discovery. Neptune has one satellite, the orbit of which is inclined to the ecliptic 145 degrees. Hence the revolution of this satellite is definitely retrograde.

On March 13, 1930, the scientific world and the general public were thrilled by the announcement of the discovery of a ninth major planet. On January 21st preceding, it had been "sighted" on a photographic plate as a faint spot, by Clyde Tombaugh, using a stereo-comparator. After this its motion was observed for more than seven weeks before public announcement was made of the discovery. Had it been a comet, it would have been observed to be moving rapidly toward or from the sun. The possibility of its being a comet was soon ruled out. By studying its motion, making allowance for the motion of the earth in its orbit, the revolution period of the new planet was approximately determined. Then its distance from the sun could be calculated from its period. This distance considered with its magnitude made possible the calculation of its size.

The new planet was found in the constellation, the Heavenly Twins, near the third magnitude star, Delta Geminorum. At Lowell Observatory it was estimated to be 15th magnitude. Since that time at Harvard Observatory it has been estimated to be 16th magnitude. It is probably about the size of the earth, at any rate much smaller than Neptune. Its distance from the sun is approximately 4,000,000,000 miles. Its period of revolution around the sun is estimated to be between 300 and 500 years.

Light, which travels 186,000 miles a second, or 11,000,000 miles a minute, takes more than six hours to come from the new planet to us. The sun's disc, if viewed from the new planet, would be about as Jupiter is to us on the earth.

Judging from the experience in the cases of Uranus and Neptune, it seems probable that the new planet will be given some mythological name in keeping with the custom.

---

*The planet was named Pluto.*

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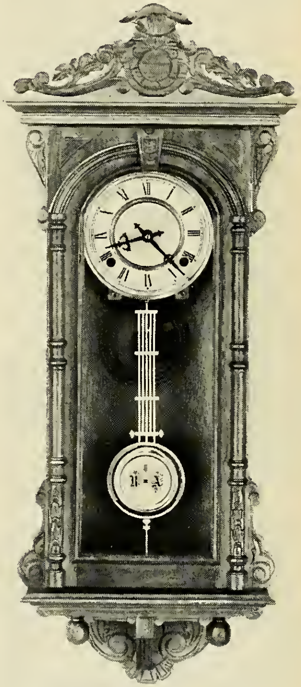

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*SEPTEMBER/OCTOBER 1925*

# THE EUROPEAN STARLING AS AN AMERICAN CITIZEN

BY FRANK M. CHAPMAN

THE American Museum may claim the doubtful honor of being the birthplace of the first European starlings to be born in this country. It was soon after their release in Central Park in 1890 that William Richardson, then of the department of taxidermy, found a starling's nest under the eaves at the northeast corner of the north wing.

Since that date, the Museum has extended its area from Columbus Avenue to the park, but in the same period the starling has extended its range, locally, from Montreal to Florida and Ohio. The one hundred birds freed in 1890 and 1891 now have millions of descendants. The starling has come to stay. Nature has accorded him his "papers" and he exercises all the privileges of citizenship.

It is a singular thing that both the starling and English sparrow were introduced into New York City by the same person. Impressed by the abundance of birds in England and by what he believed to be their comparative scarcity in this country, Eugene Schieffelin determined to make good the deficiency.

Inspired by the highest motive, he might, under proper direction, have become the father of bird conservation in America and have saved for us species we shall never see in life again. But like many another pioneer reformer, he blazed a false trail. Organizing and incorporating at Albany a society for the importation of foreign birds into New York State, he followed the introduction of the house sparrow with that of song thrushes, chaffinches, bullfinches, skylarks, nightingales, and finally the starling. Only the first and last of his attempts to transplant European birds to our shores were successful and in them he took no small amount of pride. Often, after the release of the starlings, he came to the bird department to ask whether any had been seen recently, and he was particularly pleased when he learned that a pair had nested in the building.

These observations, made immediately following the introduction of the starling, when its future in this country was still uncertain, recall the experiences of an earlier generation of ornithologists who, with equal interest, reported seeing English sparrows! I quote from the annals of the *New York Lyceum* for 1867, page 287, where George N. Lawrence wrote:

> This familiar European species has been successfully introduced in New York, and colonies have been established at several distant points, where they could have been seen during the past winter. After the extreme cold of last January (1866) when the thermometer marked ten degrees below zero, I noticed them in their usual quarters, apparently unharmed. In Jersey City, also, they are quite numerous. I first observed them in the spring of 1865. A friend, conversant with our local native birds, informed me that he had seen a species in the shrubbery around the church on the corner of 5th avenue and 29th street, with which he was not familiar; on going to ascertain what they were, to my surprise I found them to be house sparrows; they were domiciled in the ivy which grew on the walls of the church, and were quite gentle and fearless, some alighting in the street and dusting themselve quite near to where I stood. I afterwards learned from our associate, Mr. Eugene Schieffelin, that he had been looking after them with much interest; in fact he is entitled to the credit, in a great measure, for this important acquisition to our city. In 1860, and for three years thereafter, he yearly set free five or six pairs, mostly in the neighborhood of Madison Square; seven pairs were let out in the Central Park by the Commissioners, in 1864.

After becoming thoroughly established in the upper part of New York City, the starling began the campaign for the acquisition of territory which is still in progress. Following shore lines it spread north, east, and south, and within ten years appeared at Ossining, New Haven, and Bayonne. Another ten years saw it near Providence and Philadelphia and in 1920 it was known from Maine to Virginia.

Having colonized the coastal region, like other emigrants from over seas, it began to penetrate the interior. It reached Ithaca, New York, in 1916, and the same year was found at West Lafayette, Ohio, the first known appearance of the species west of the Alleghenies.

The Plains, the Rockies, and the Sierras will probably prove obstacles in the starling's course, but no doubt he will surmount them and sooner or later establish himself throughout the greater part of the country.

During the thirty odd years of the starlings' residence in America, none of our native land birds has appreciably increased in numbers. How, then, has the starling, starting from a few pairs, become more abundant than many of them? In attempting to answer this question we discover some of the factors governing the comparative abundance of species. In the first place, it is evident that the starling has filled a place (technically, an "ecological niche") not occupied by a native species. Without in any way disparaging the American Museum as a home for birds, indeed we always welcome them, what American bird, left to its own resources in Central Park, would have reared a family under our eaves? The European house sparrow (which we insist on miscalling the "Eng-

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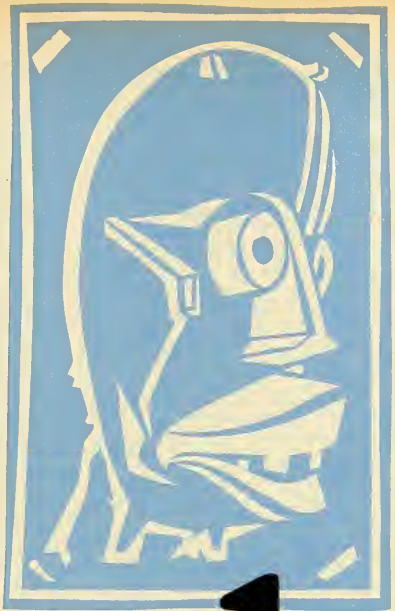
g for you.

The African mask is not a
sguise. Nor is the wearer a man
etending to be a god. Rather,
ask and man become a god who
visible in its real form.

Music and dance were the
st African arts to attract the at-
ntion of travelers and histo-
ans. A shield from ancient
reece depicts an African
umpet player. African sculpture
as not appreciated until the end
the 19th century.

Among the Dan people who
/e in the Ivory Coast, the impor-
nce of a mask is in proportion to
s size. The biggest, most impres-
ve ones, the "Masks of Peace,"
e sufficiently powerful to end
ostilities between villages.



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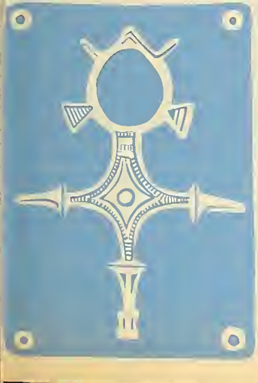
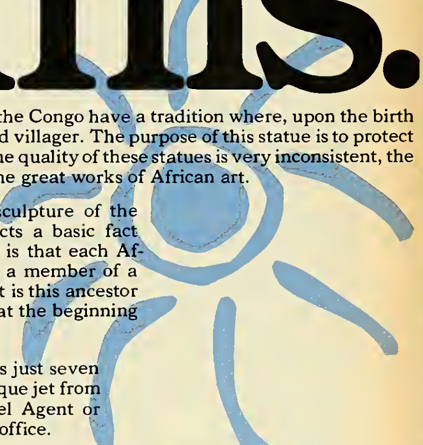
The Cross of Agadez,
ɔne of the most famous silver
ewelry designs in all of Af-
rica, is worn by the Tuareg
people of the south Sahara
desert in Niger.



The Bateke people of the Republic of the Congo have a tradition where, upon the birth of a boy child, a statue is carved by a talented villager. The purpose of this statue is to protect the boy until he reaches puberty. Although the quality of these statues is very inconsistent, the best of them are worthy of a place among the great works of African art.



Ancestors appear frequently in the sculpture of the West African people. This emphasis reflects a basic fact about the nature of African existence, that is that each African is what he is and has what he has as a member of a family, i.e., the descendant of an ancestor. It is this ancestor sculpture that so amazed European cubists at the beginning of this century.

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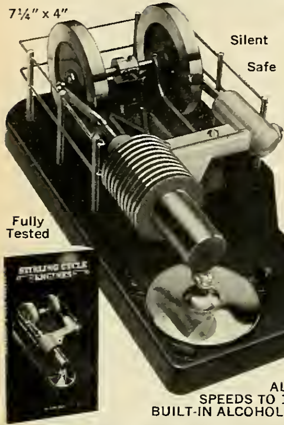

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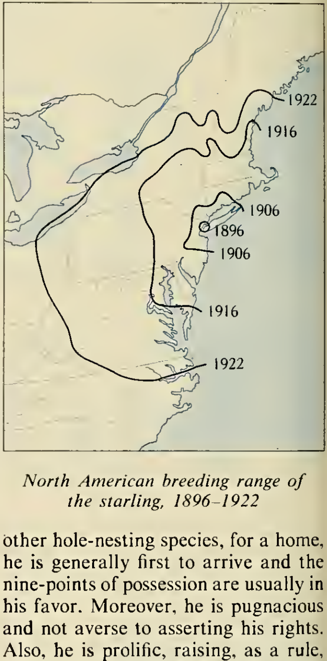
lish" sparrow) could and does, and like the starling it has succeeded. It is this ability to adapt themselves to circumstances which, primarily, has enabled these aliens to survive and flourish in America. Again, like the sparrow, the starling is hardy and non-migratory. This means that he can withstand wide climatic variations and, in default of an inherited habit which would lead him over routes followed by our birds, that he runs no risk of flying out to sea, or to some other place whence he might never return. It is true he wanders about after the nesting season, but his movements are largely governed by a search for food and probably do not carry him far from his nesting place.

When, therefore, he does have to compete with flickers, or bluebirds, or other hole-nesting species, for a home, he is generally first to arrive and the nine-points of possession are usually in his favor. Moreover, he is pugnacious and not averse to asserting his rights. Also, he is prolific, raising, as a rule, two broods, of which, because of the protective character of the nest-site and defensive ability of the parents, a comparatively large percentage doubtless reach maturity. Need of only limited territory when nesting is also presumably responsible for the starling's rapid increase. In some birds sexual jealousy is so highly developed during the season of reproduction that they will not permit another pair of their own species to nest near them. But, I have recently heard of five pairs

Joe LeMonnier



*North American breeding range of the starling, 1896–1922* of starlings nesting simultaneously in the hollow limbs of a single willow tree. Add to these various traits, omnivorousness in feeding habits, and we have some of the reasons why the starling has multiplied and spread.

Having with thoughtless hospitality accorded the starling, house sparrow, San José scale, gypsy moth, and other pests, including certain members of the genus *Homo,* free and unchallenged entry to our ports, we now ask (if to our sorrow, we have not already learned), "Are they desirable?" So far as the starling is concerned the question is not to be answered in a word. It can, however, be answered for we have to thank American economic ornithologists for the most exhaustive study of the starling's food habits which have as yet been made.

The starling is here considered under three counts: (1) its food habits, (2) its relation to other species, (3) its direct relation to man. The study of the starling's food has been conducted with great thoroughness and the results reached doubtless adequately express the bird's economic status at this period of its American history. They are summarized as follows:

As an effective destroyer of terrestrial insects, including such pests as cutworms, grasshoppers, and weevils, the starling has few equals among the bird population of the northeastern United States.

The most serious objection to the starling on economic grounds arises from its destruction of cherries. When its work is combined with that of the robin, which is fully as destructive and much less easily frightened, the chances for a successful crop of cherries, especially of early varieties, are poor.

The starling's work on apples is confined largely to isolated trees and to small, old orchards. Late varieties suffer more than those which mature at a time when there is still a great abundance of wild black cherries available. In the aggregate the apple damage is not great and is practically absent in young, well kept, productive orchards. Injury to peaches and pears is negligible, and the damage to grapes is at present confined to small arbors–the large vineyards suffering very little.

An idea of the economic significance of the starling's food habits is gained by comparison with the food habits of certain well-known native birds, with some of which it frequently associates. A thorough consideration of the evidence at hand indicates that, based on food habits, the adult starling is the economic superior of the robin, catbird, flicker, red-winged blackbird, or grackle. It is primarily a feeder on insects and wild fruit—less than 6 per cent

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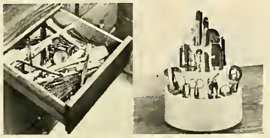

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of its yearly food being secured from cultivated crops. What damage it does inflict is due not so much to the character of its food habits as to the fact that the flocking habit has allowed some minor trait to be emphasized to a point where local damage results. The decidedly beneficial character of the food habits of one, two, or sometimes three broods of nestlings, numbering 4 to 6 to the nest, adds materially to the favorable economic status of the species.

The starling's competition with American birds is largely restricted to those that nest in holes and similar sites. This includes chiefly the bluebird and flicker. The former is no match for the relentlessly persistent alien and even the flicker's larger size does not always prevail against the starling's aggressive tenacity.

Conflict over the food supply is negligible in summer, but serious in the autumn and winter. For example, a dogwood bearing a crop of berries sufficient to supply a group of gentle-mannered hermit thrushes with food for a fortnight will be stripped by a flock of starlings in a day. As a result, the thrushes continue their migration southward to winter beyond the present range of the starling. But it is apparently only a question of time when the starling will be abundant in winter at least throughout the Gulf States where it will claim no small part of the food supply of our native species.

There are times when the starling makes such strong demands upon our hospitality that even its friends resent its presence. This is during the late summer and early autumn when the vast flocks of birds select a city park or village lawn as a roosting place. Grackles, robins, and martins are often associated with them and the whole may number many thousands. To the ornithologist such gatherings possess great interest, but the tired business man, who has come home to sleep, not to study avian communism, sees in them only a source of noise and filth, and spares no effort to induce the birds to move elsewhere. Frequently, however, he finds it difficult to convince them that they are not welcome. The usages of civilization forbid the murder of even the most undesirable guest, and in default of firearms, Roman candles have been effectively employed. Discharged into trees laden with sleeping birds, they create consternation without fatalities and finally make it plain to the feathered throng that, while we may encourage their coöperation in our gardens we

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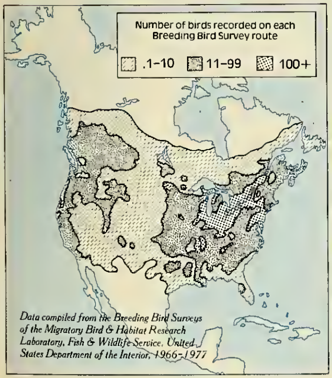
can dispense with them after nightfall. But the direct contact of the starling with man extends far beyond its roosting habits. These other relations, however, belong among those "imponderables" which science can neither weigh nor measure. They have to do with the personality of the starling, with its standing as a citizen and as a neighbor.

When a stranger enters an established community, he is bound, more or less, to disturb existing conditions, and the extent and nature of the local reaction to this disturbance determines his community status.

Viewed from this standpoint the starling is heavily handicapped. In the first place he is a foreigner. Now whatever we ourselves may be, whether our forbears came over in the Mayflower or on the Mauretania, there can be no doubt that our birds are Americans. As such they are not only the products but expressions of their environment. When, in early March, a moving nebulous blur resolves itself into a flock of redwings, they are less birds than the Spirit of Spring. But if the hurrying smudge becomes a passing troupe of starlings, we regard it with disappointment or indifference. It has no seasonal significance.

So the notes of the wood pewee voice the dreaminess of a mid-summer day —uttered by the starling, they are a mimetic travesty. But, after all, it is only the chosen few who cherish these intimate associations with nature that resent the starling's violations of them. To by far the greater number of those who notice him at all, a starling he will be and nothing more.

*North American breeding range of the starling, 1977*



*Data compiled from the Breeding Bird Surveys of the Migratory Bird & Habitat Research Laboratory, Fish & Wildlife Service, United States Department of the Interior, 1966–1977*

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# TAUNGS AND ITS SIGNIFICANCE

## BY RAYMOND A. DART

MAN is an omnivorous, bimanous, and bipedal, almost erect, terrestrial mammal. The highest living anthropoid apes are frugivorous, quadrumanous (or quadripedal), semi-arboreal, semi-erect mammals. It is believed that man arose from a semi-arboreal ancestor, to which the highest living apes are the nearest mammalian relatives, and that this semi-arboreal ancestor sprang, in turn, from an ancestor who was entirely arboreal in habit. Indeed, there are those who believe, that not merely man and all his near relatives, the Primates, but the whole mammalian stock came from ancestors who at one time lived entirely in the trees. We are not concerned here with this more remote origin of the Primates other than to note that they are tree-livers and that their ancestors were tree-livers from the earliest mammalian times.

In order to achieve his so-called erect posture and terrestrial mode of life, the monkey that was to be man had to pass through a severe apprenticeship, of which there were two initiatory phases, before he entered the third phase or true freemasonry of manhood. These two phases were firstly, the semi-arboreal (or semi-terrestrial) which is typified by the living anthropoid ape; and secondly, the entirely terrestrial man-ape phase which has been hitherto typified by one representative only —the man-ape of Taungs [*Australopithecus africanus*], found in Bechuanaland, South Africa.

It has long been recognized by naturalists that two such phases in man's evolution were probable; of the first phase we have in the four living anthropoids and many extinct ones a great deal of information concerning not only its essential characteristics but also its site of operation, i.e., in the tropical or subtropical forest zone. The second phase has been appreciated only as a theoretical necessity, and the scene of its occurrence has been purely a subject of conjecture.

The Taungs remains show that this second phase was a living reality; they demonstrate that man did not arise "Minerva-like in full panoply" as a sudden sport from some semi-arboreal ape, but that the anthropoid achieved human status by laborious passage through the terrestrial man-ape phase; finally they indicate, if they do not actually prove, the quarter of the earth upon which this penultimate act in the drama of humanity was staged.

It is in these matters that the Taungs remains have their significance. They have rendered real what hitherto has been theoretical.

The Taungs limestone deposit is a cliff at whose feet, to the east lies the treeless (save for shrubs) valley of the Harts River and whose plateau crest, equally devoid of forest, stretches west into the Kalahari desert. The temperature at Taungs fluctuates from 120° F. in summer to severe frosts and biting cold winds in winter. The average annual rainfall is about five inches.

It is an area which impresses one, by its heat in summer, and its cold in winter, and by its lack of rain, of woods, of grass, of running water, and all things delectable, as the most inauspicious spot for man's forerunners. It is a region once thickly populated by Bush people and is now a native reserve occupied by a bastard Bush-Bantu race of Bechuanas. But areas such as this, habitable by mankind through his adaptability, his intelligent use of weapons, and his quickness of movement, are not habitable by the lumbering anthropoids of the tropics.

Hence, the appearance of *Australopithecus*, roughly on the latitude of Johannesburg, was most unusual and unexpected and can be explained only by the fact that *Australopithecus* has partaken of those characterstics which separate man from the anthropoids and make it possible for him to exist in such untoward environments. This belief that *Australopithecus* profoundly differed from modern apes becomes more reasonable when we consider the geographical situation of Taungs. Lying in the Orange River

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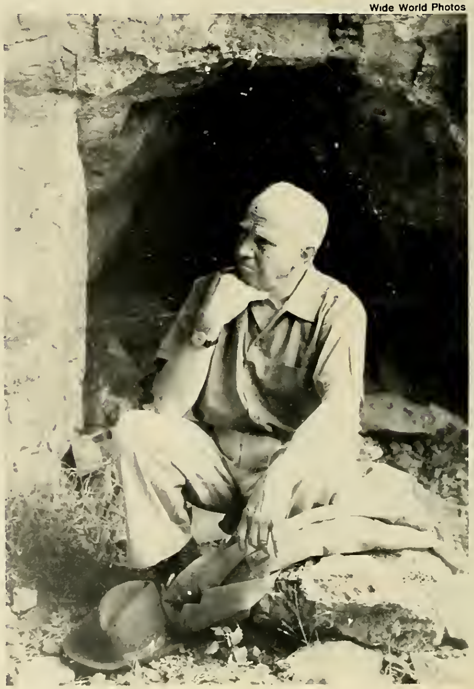

*Raymond A. Dart*

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watershed, it is separated from the Zambesi watershed by a vast open tract of country which, to the west (from Western Rhodesia to the Atlantic Ocean) is the Kalahari desert, and to the north and east (throughout Rhodesia and the Northern Transvaal) is occasionally wooded but is mostly treeless prairie or veldt country. There is no woodland approach to Taungs from the north, east, or west. This open and in large part barren country, interposed between the tropical forest and Taungs is, and has been from Cretaceous times, an effective barrier against the migration of the semi-arboreal anthropoids of Africa—the chimpanzee and gorilla.

The efficiency of this barrier against the migration of the living anthropoids cannot be stressed too greatly when we call to mind the fact that during Tertiary times that barrier of desert and plains has been effectively reinforced by the fearsome carnivorous enemies of Primates, whose possession it was. It is obvious, *prima facie,* that the Australopithecoid group which forced this barrier into the remote Southland had evolved an intelligence (to find and subsist upon new types of food and to avoid the dangers and enemies of the open plain) as well as a bodily structure (for sudden and swift bipedal movement, to elude capture) far in advance of that of the slothful, semi-arboreal, quadrupedal anthropoids. They had thus attained a degree of physical and psychical advancement that sundered them irrevocably from their tropical cousins. It is equally clear that those who had successfully traversed the barrier and established their capacity to live in the latitudes of the Vaal had no serious barrier interposed between them and the southern extremity of the continent.

We may therefore reasonably indulge the greatest hopes of the discovery of youths and adults of the same and allied species in any part of Southern Africa, especially the Eastern coastal areas where the climatic and botanical conditions are so much more amenable for Primate existence.

The formidable nature of the land and animal barrier together with the vicissitudes of life, to which this Australopithecoid group was continually exposed in this country, is the more important to bear in mind since the factors which evoked the thinking and planning powers of the anthropoid, and, with these powers, caused the transformation from anthropoid to

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man, are to be sought, not in any cataclysmal upheavals of nature, or fortuitous saltations of the germ plasm, but rather in steadily and continuously operating environmental conditions which constantly and increasingly demanded the operation of choice and cunning.

Such an environment is certainly not to be found in any land belt containing the easy refuge of trees where the return to semi-arboreal existence was possible as, for example, throughout Southern Asia and the Eastern Indies.

Just as for the expansion of the brain so, for the evolution of a more erect posture, in which reliance would be placed upon the feet and not at all upon the hands, it was essential that a large territory should be available in order to make it impossible to return to the forest. In this way the anthropoid group should be committed over a countless number of years to the use of their upper limbs for fight and their lower limbs for flight. An environment of this type was present, because of the barrier already mentioned, from the Cretaceous times onward in Southern Africa; and Southern Africa is the only country which has elicited, hitherto, an anthropoid individual betraying features such as one might expect to result from the operation of these unremitting and compelling environmental conditions.

With reference to the epoch at which the fossil was embedded in the limestone, there is bound to be much doubt until we know considerably more about the geology of the deposits themselves, and the general question of ageing deposits in Southern Africa. From a consideration, firstly, of the position of this specimen in the cliff; secondly, of the intensity of the infiltration of the lime to form the hard stone in which it was embedded; and, thirdly, of the fact that there is ample evidence in the cliff itself that sand was being incorporated in the cliff during the depositing of the lime, I am of the opinion that the limestone was deposited irregularly leading to the cavernous structure, and that the interstices were filling up with sand from a very ancient period, in large measure contemporaneously with the lime deposition.

In his notes on the baboons found at Taungs which he has kindly placed at my disposal, Doctor Haughton remarks, "It is certain that the sandy patches in the limestone and the bones

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embedded in them are of the same age as the main body of the limestone."

Since there was a certain growth forward as well as in height during the lime deposition, both the horizontal depth (250 ft.) as well as the vertical depth (50 ft.) at which the remains lay have a degree of significance. In other words I look upon the fossil as Tertiary and embedded while the lime formation was still in progress.

Since that time a ravine about one hundred feet in depth and nearly three-quarters of a mile long has been worn through the hard calcareous tufa when it was the original course of the tiny Thabaseek "river," a sluit or creeklike tributary of the Dry Harts River.

Later the "river" was diverted to its present course northward of the tufa through the softer shales, and has worn its bed to a point some two hundred feet below the top of the cliff. How long it has taken for these processes to become completed it is difficult to say, but in view of the fact that years may elapse without any running water ever passing over the "waterfall" at the head of the gorge through the plateau's edge and along the stream bed, and the further fact that water rarely, if ever, is running during a whole week in any year that rain falls—when of course it may be a raging though small torrent for a couple of days—it is impossible that the work of erosion could have been rapid. It is hardly necessary to say that in the period during which the area has been known, i.e., the last half-century, no appreciable alteration of the conformation of the stream or its channel has been recorded. Assuming for the sake of argument a uniform rate of backward erosion of ⅛ inch per annum, it will be seen that some 125,000 years were necessary for the formation of the dry ravine which is from 50 to 250 feet broad—the cutting of the modern river bed taking perhaps a somewhat briefer but additional period. At all events it is reasonable in the present state of our lack of knowledge to estimate the age of the river bed in terms of hundreds of thousands of years—possibly, as one has suggested, contemporaneously with the uplift of South Africa in the Pliocene. In any case the deposition of the lime deposits took place prior to that period, i.e., prior to the formation of the dry ravine and the present river bed, and so at a very remote period, probably pre-Pliocene. There is no evidence to indicate

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Victoria's Secret

that the Taungs man-ape did not inhabit the district in those days of lime deposition.

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When Dart discovered the Taung skull and wrote his famous 1926 article for *Natural History*, anthropologists were divided in their responses to the extraordinary claims from southern Africa. There was uncertainty about many aspects of the strange creature: its geographical dispersal, antiquity, diversity, way of life, and place on the evolutionary tree. Almost everyone doubted Dart's outlandish claim that a creature with a brain size scarcely different from that of the apes, and one-third as big as that of modern man, could have been a near relative of the human species. They also doubted that humanity had its origins in Africa.

In the ensuing years, Africa's sedimentary deposits and dolomitic cave formations have yielded a broad array of evidence that has answered many of the questions provoked by the Taung skull in 1926. Fossils of *Australopithecus* have emerged from the Transvaal, Tanzania (where Olduvai is located), Kenya, and Ethiopia. Convincing specimens of *Australopithecus* have not yet been found in Asia or Europe. So far, *Australopithecus* represents an early African phase in human evolution.

The application of new technology has given insights into the age of *Australopithecus*. The earliest well-attested members are dated to just under four million years ago. A few older specimens, which might have represented the same group, might possibly take the earliest known members to over five million years. Thus, the genus existed during the Pliocene epoch of the Tertiary period and persisted into the Pleistocene, the first epoch of the Quaternary period. The most recently dated forms lived about a million years ago. Thereafter, *Australopithecus* disappeared from the record. The dating of the Taung skull itself is still problematical, however; estimates of its age hover between 1,500,000 and 750,000 years.

Careful anatomical studies have shown that most of the features of *Australopithecus* relate them to human beings. They walked upright, as Dart originally inferred; their hands, pelvises, legs, and feet were humanlike in structure; their brains, although small, resembled miniature human brains rather than ape brains; their teeth, although large, showed a human rather than an ape pattern. They are classed as hominids, or members of the human family.

Several kinds or species of *Australopithecus* occurred. The earlier ones, which lived mainly in the Pliocene, were gracile; they belonged to the species *A. africanus*. The later ones, which lived in the end-Pliocene and on into the Pleistocene, were a heavily built Transvaal version, *A. robustus*, and an extremely large-toothed, sturdy East African form, *A. boisei*.

Most scientists agree that the earlier, gracile *A. africanus* was most likely to have been on or close to the lineage leading to the genus *Homo; A. robustus* and *A. boisei*, on the other hand, were a specialized branch that died out about a million years ago.

Although scientists still argue about the names to be assigned to various fossils, there is nearly universal agreement that some populations of *Australopithecus* were most likely to have been ancestral to modern man. With hindsight, we see that Dart was right when he claimed that a small brain alone was not sufficient to disqualify the creature from the exalted company of hominids.

*Phillip V. Tobias*

*Paleoanthropologist Phillip V. Tobias holds the same position in the Department of Anatomy at the University of the Witwatersrand in Johannesburg, South Africa, that Raymond Dart occupied fifty-five years ago when the Taung skull was discovered. Since 1977 Tobias has also been an honorary professor of paleoanthropology, and this year became dean of the medical faculty, a position Dart also held.*

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# THE JAPANESE EARTHQUAKE EXPLAINED

BY CHESTER A. REEDS

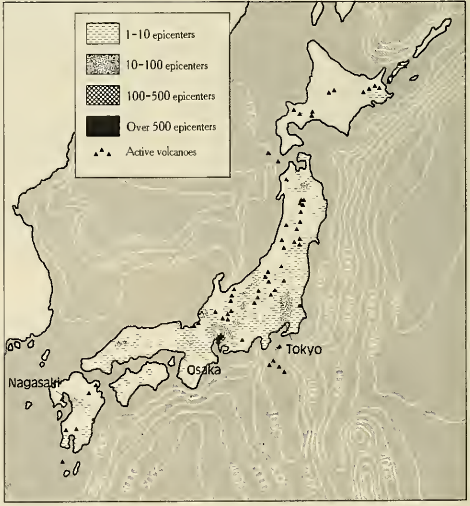
At noon on Saturday, September 1, 1923, Tokio time, the Empire of the Rising Sun was stricken by a power beyond human control. A violent earthquake shook Tokio, Yokohama, Yokosuka, Odawara, Hakone, Chiba, and other points about the Bay of Tokio. Shortly thereafter fires arose in Tokio and Yokohama and almost entirely destroyed those cities. Seismic sea waves were also reported in some dispatches and contradicted in others. At any rate, the devastated region was completely isolated from the rest of the world for days. There were more than 3,000,000 people in the stricken zone at the time of the catastrophe and the loss of life and property was so great that even a week or more after its occurrence, reports were still far from being complete.

This great earthquake was registered on seismograph instruments on the opposite side of the earth and at intermediate stations. The arrival of the first set of earth waves in the eastern part of the United States was registered at 10:12 P.M., Friday evening, August 31, the main waves shortly before 11 o'clock, and the last waves at 3 A.M., September 1. It may be stated here that due to the recognition of the international date line along the 180th meridian, the corresponding time in New York and Washington was Friday, and due to the difference in longitude of ten hours the time here was 10 P.M., August 31, 1923. Some dispatches state that in Tokio the initial heavy shock lasted not more than six minutes. Whatever may have been the brief duration, the waves which arose from this shock were spread out for five hours on the seismographs in the eastern part of the United States. According to dispatches from the Imperial Meteorological Station more than a thousand "after-shocks," which were not recorded on distant seismographs, accompanied this quake.

The earthquake map of Japan prepared by Dr. Charles Davison in 1921 exhibits in a striking manner the earthquake and non-earthquake regions as well as the location of the eighty-eight volcanoes on or near the principal islands of Japan. This map indicates that the central portions of Japan, where active volcanoes are numerous, are singularly free from earthquakes. A perusal of Prof. John Milne's catalogue of Japanese earthquakes, in which 8331 are listed between the years 1885 and 1892, shows that to every quake that was volcanic there were five that were non-volcanic.

The Japanese Islands form an arc or festoon with the convex side facing the Pacific Ocean. Furthermore, the submarine features are of special interest. From the contour lines for each thousand meters in depth it may be observed that the Japanese Sea is shallow, with its greatest depth a little over 3000 meters. The Pacific Ocean, on the other hand, is very deep. The extraordinary basin called the Tuscarora Deep reaches a depth of 8000 meters at distances of from 110 to 240 miles from the coasts. The gradient is unusually steep, being 1 in 27 off the coast of Nemuro, a maritime village on the island of Yezo, 1 in 30 off the northeast coast of Hondo, or the main island, and 1 in 16 (to a depth of 3000 meters) off the southeast coast of Kazusa and Awa, near Tokio.

Prof. F. Omori, the Japanese earthquake specialist, has listed 221 destructive earthquakes in Japan occurring from the fifth century to the present. Of the total number, 114 originated inland, 47 under the Pacific Ocean, 17 under the sea of Japan, 2 under the inland seas, while the epicenters of 41 earthquakes are unknown. Of these earthquakes 10 were very violent: 3 of them occurred in central Japan, and 7 originated off the southeast coast, each of the latter being accompanied by seismic sea waves. During the same period there were 23 great sea waves on the Pacific coast and only 5 on the Japan Sea.



*Davison's seismic map of Japan, based on Milne's list of 8331 earthquakes for the eight years 1885–92, shows that the number of earthquakes recorded in the Tokio district during this period was less than ten; also that the 88 volcanoes are distributed throughout the mid-western portion of the islands, except the Fuji chain to the southwest of Tokio.*

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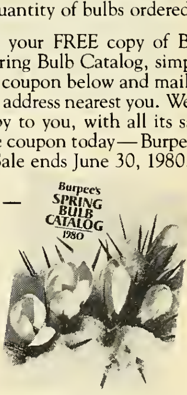

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Similar results followed from Omori's examination of recent strong Japanese earthquakes. From 1885, when the systematic observation of earthquakes was begun, to 1905 there originated in or around Japan 257 earthquakes, some of which were destructive while the rest, although not involving great loss, were nevertheless strong or moderate shocks each having disturbed land areas of more than 25,000 square miles. The most active region at present stretches off the east coast of Yezo and Hondo, the number of earthquakes which occurred in it being rather more than half the total number in Japan. It is no great surprise therefore to find that the violent earthquake of September 1, 1923, took place in the Tokio district near the steep Pacific side.

An earthquake has been explained as the result of any sudden displacement within the earth's crust. It may have a tectonic or a volcanic origin. Tectonic earthquakes are due as a rule to the displacements which effect the growth of faults or fractures in the earth's surface. Volcanic earthquakes may be considered as those which are caused by volcanic eruptions or displacements along fractures of the volcanic mass, whether the volcano be active, dormant, or extinct. The volcanic earthquakes are of two kinds: first, those which are purely volcanic in their origin, and second, those which are somewhat tectonic in character.

From seismograms taken on certain active volcanoes of Japan, Omori divides the volcanic earthquakes into two groups: (1) those due to earthquakes which were not accompanied by any outburst of the volcano, and (2) those due to earthquakes which were invariably coincident with the explosions. The first group consisted only of simple quake vibrations; the second group began with slow tremors on which, after a few seconds, quick vibrations were superimposed. The earthquakes without explosions were distinctly the stronger, for of the 14,085 shocks of this character recorded from 1911–16, 21% were sensible, while of the 8847 quakes with explosions only 0.3% were sensible.

Tectonic earthquakes, the greatest of all, occur in regions somewhat distant from volcanoes or far removed from present or past volcanic action. They are due either to displacement along faults or to the warping of surface beds of rock in the earth's crust. As might be expected, faulting (the

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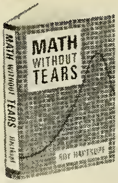

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slipping of adjacent blocks of the earth's crust on one another along a fault-plane or fracture) predominates over warping in producing earthquakes. The connection between the crustal deformations and the earthquakes is shown by the coincidence between their times of occurrence and the areas affected by them. It is important, however, to notice that the deformations are not consequences of the earthquakes but rather the primary causes of the earthquakes. The number of earthquakes accompanied by crustal deformation is considerable. In many cases, however, the observations recorded add little to our knowledge beyond the fact that some movement usually of elevation has taken place. The principal reasons for connecting earthquakes with fault slips are the following: (1) with every step in the growth of the fault it is evident that an earthquake must occur; (2) in some great earthquakes the fault displacements are manifest; (3) in all but the weakest earthquakes the areas of greatest disturbance are elongated in form, their longer axes being parallel to the fault lines of the district; (4) the number of earthquakes in any region far exceeds the number of the faults; (5) in a series of associated earthquakes the center of the disturbance migrates to and fro in the direction of the fault; and (6) owing to the variations in the volume and displacement of the rock mass, fault slips are capable of producing the weakest tremor as well as the most violent shock.

The displacements along a fault may be almost entirely horizontal or almost entirely vertical, but in most cases they are both horizontal and vertical. Horizontal displacements are usually manifested by the relative shifting of objects previously in contact or in line; vertical displacements by the formation of fault scarps.

The great earthquakes which remove over-strained conditions in the earth's crusts occur after short lapses of time at different places in the seismic belt or related earthquake zones. They seldom, if ever, recur at one or the same spot, for the earth's stresses, having been temporarily adjusted at that place, accumulate in the adjacent seismic regions. Thus the Japanese earthquake of December 23, 1854, took place off the coast of Tokaido, while the equally extensive shock on the next day originated from the same earthquake zone 200 miles to the west, off the coast of Nankaido. Sympa-

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thetic stresses accumulating in widely separated parts of the Pacific seismic zone have been noted as follows:

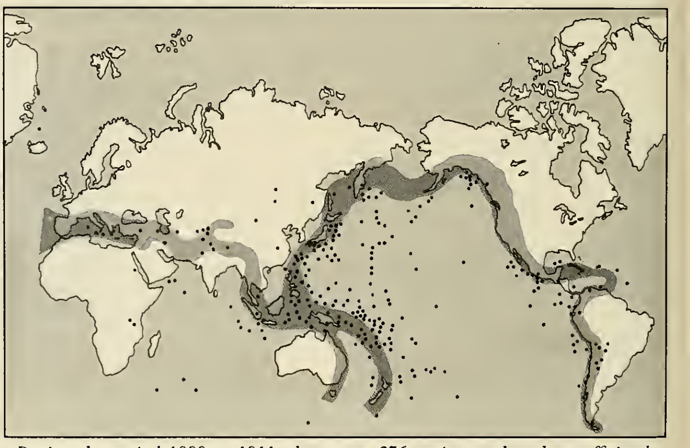
(1) Off the northwest coast of Alaska in 1899.
(2) Mexico and Central America, 1900 and 1902.
(3) Panama, Colombia, and Ecuador, February 1, 1906.
(4) San Francisco, April 18, 1906.
(5) Aleutian Archipelago, August 16, 1906.
(6) Valparaiso, August 16, 1906. (Note that Nos. 5 and 6 occurred on the same date, No. 5 occurring half an hour earlier than No. 6.)
(7) Chile, November 11, 1922.
(8) Six hundred miles northwest of San Francisco on the line of the San Andreas fault, January 31, 1923.
(9) South Pacific Ocean, February 3, 1923.

In this connection it is interesting to note that after the great Japanese earthquake of September 1, 1923, a sympathetic quake occurred in Calcutta, India, on September 10, and another one in Paotingfu, China, September 14, 1923.

A larger view of the problem is necessary in order to understand some of the underlying causes of the recent Japanese earthquake and of other earthquakes. In the distribution of earthquakes are to be found the loci of the most pronounced earth movements today, that is, the zones of present maximum change in the strained figure of the lithosphere, or solid part of the earth. In the case of the continental areas we have long known the position of the earthquake districts. The earth's crust trembles predominantly along two narrow zones which lie along two great circles of the earth known as the Mediterranean, or Alpine-Caucasian-Himalayan circle, and the circum-Pacific, or Andean-Japanese-Malayan circle. As to parts of the ocean floor which have been affected by these movements, it is only during the present generation that methods have been perfected for locating the sites of earthquakes beneath the seas. Modern seismographs, or earthquake-registering instruments, now record the sudden movements of the earth's surface quite independent of whether they occur at the bottom of the sea, upon distant islands, or upon the continents. The centers of large earthquakes, determined by the late Prof. John Milne for some fifty odd stations of the British Association for the years 1899 to 1911, appear as dots on the map on this page. It will be noted that the continental earthquake districts extend outward for a distance on the floor of the neighboring ocean and that the disturbances are more numerous for the undersea areas and belts of festooned archipelagoes east and southeast of Asia.

It may be noted further that the two main seismic belts are closely related to the geosynclines, or areas of sedimentation, dominant folding, and uplift during Cenozoic time, that is, during the last era into which geologists divide geologic time. This area may represent a period starting 3,000,000 years or more ago and continuing down to the present. The areas of dominant folding and uplift during Cenozoic time have been superimposed as shaded zones on the accompanying map. These two major circles of earthquake disturbance include within their limits the arcuate mountain folds known as the Pyrenees, Alps, Carpathians, Caucasians, and Himalayas of Eurasia and the Cascadian and Andean mountain systems of North and South America. These great mountain masses began their existence in the early part of the Cenozoic era and from their grandeur we might judge that they are almost completed, but from the rather frequent earthquakes that occur in and about them we must conclude that the earth forces which built them are still active although in their relative maturity. The mountains themselves are young and although not all of them are in the same stage of development, they are in their prime. The festooned island groups, however, such as the Japanese archipelagoes and similar arcuate forms off the southeast coast of Asia, as well as the Aleutian and West Indian arcs, represent younger mountain chains of the late Cenozoic age which are not yet fully exposed but are rising from the floor of the ocean.

Japan, the land of "cherry blossoms," is an island empire rising out of the sea. To most Americans Japan presents a detached group of mountainous islands beset with numerous volcanoes and frequented by earthquakes. The oceanic waters which surround these islands hide the stupendous mountain topography and the structure which powerful earth forces have already built up and which they are still erecting off the coast of Asia. Volcanoes and earthquakes are associated with the forces that build mountains, for they perform much the same function that safety valves do on a steam locomotive. For centuries Japan has had destructive earthquakes. Omori, who has studied many of them, concludes that the maximum epochs of destructive activity recur on an average every 13 or 14 years. From the nature of the case we may thus conclude that earthquakes will occur in Japan at rather frequent intervals for centuries to come. This prophecy, however, should not dishearten the Japanese nation, for, besides its own progressive development, it can take courage from the fact that the Babylonian, Egyp-



*During the period 1899 to 1911, there were 276 major earthquakes sufficiently severe to be recorded at all seismological stations scattered over the world. The epicenters are shown on the map as heavy dots. The close association of recent quakes to the belts of sedimentation, dominant folding, and mountain uplift (shaded zones) during recent geologic time (Cenozoic era) is very marked.*

tian, Grecian, and Roman civilizations developed about the Mediterranean, despite the fact that this region lies in one of the world's active seismic belts.

The Japanese nation is aware of its acute situation, for in accordance with an Imperial Ordinance dated June 25, 1892, the famous Earthquake Investigation Committee of Japan was organized. Its objects were to be: "In the first place to investigate whether there are any means of predicting earthquakes; and in the second place to investigate what can be done to reduce the disastrous effects of earthquake shocks to a minimum, by the choice of proper structures, materials, positions, etc." The Committee has included some of the most brilliant men of Japan and has now worked enthusiastically and tirelessly for thirty years; but no method of forecasting quakes has been discovered and the second endeavor is the only one which had been crowned with some success.

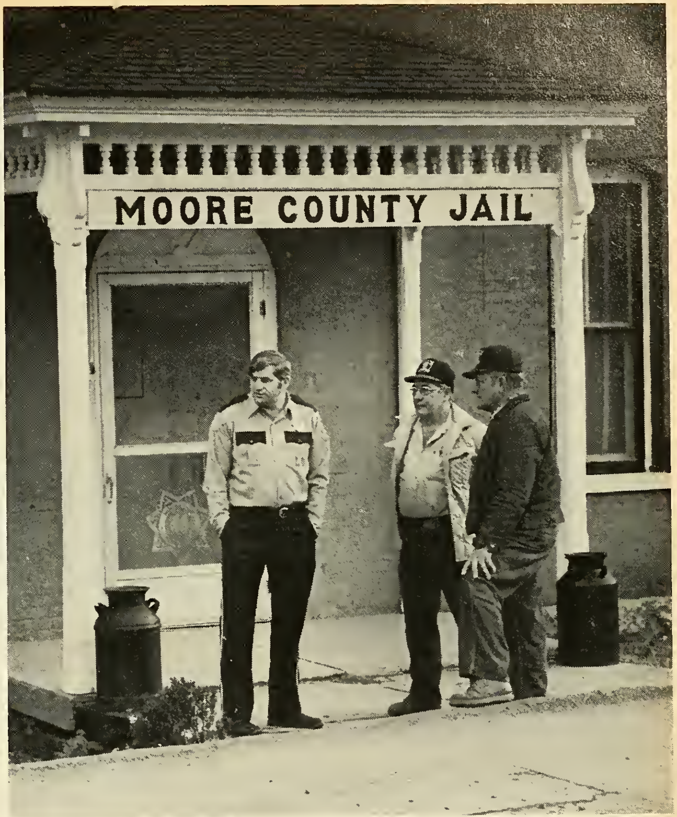
---

A moderate earthquake that struck near Coyote Lake, California, about sixty miles southeast of San Francisco, in August 1979, has cast serious doubt on hopes that reliable prediction of such an event will be possible in the near future. The quake, of 5.7 magnitude, occurred on the Calaveras fault, a major branch of the San Andreas fault, without any warning even though it fell within a dense network of monitoring equipment designed to detect just such an earthquake.

None of the usual short-term precursors of moderate quakes—clusters of small quakes, tilting of the earth's surface, or changes in the geophysical properties of the crust—were observed. This has caused great concern because evidence suggests that it is this type of moderate shock that triggers great, catastrophic earthquakes.

The feeling among some scientists is that the Coyote Lake quake may be an example of a class of nonpredictable earthquakes. The problem seems to be that, under certain conditions, small areas of high stress along a fault could make quake precursors hard to find. The level of stress necessary to produce a given precursor may be reached, but the precursor warning might appear over only the small area of the stress and not over the length of the fault. Or the stress may not be high enough to produce any precursors before the breaking point of the fault is reached.

In 1977, the funding of this country's earthquake prediction program was tripled. At that time, the estimate was that it would take ten years before instrument networks "captured" enough earthquakes of the right type to determine the practicality of earthquake prediction. After Coyote Lake, those in the business feel that it could take much longer.



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Organized by the celebrated explorer Roy Chapman Andrews and sponsored by the American Museum of Natural History, the Central Asiatic Expeditions consisted of five journeys into Mongolia and China, undertaken between 1922 and 1930. This extraordinary venture resulted in the first systematic study of what was then one of the earth's least-known regions—the Gobi Desert. Audacious in concept, brilliantly planned and executed, the Central Asiatic Expeditions constituted the largest, best-equipped, and most costly program of land-based exploration ever launched from the United States up to that time. The budget totaled nearly $700,000—an unprecedented sum for such a project—and at the height of the most ambitious season, in 1925, the expedition included fourteen scientists and technicians, twenty-six native assistants, five touring cars, two trucks, and a caravan of one hundred twenty-five camels.

Using automobiles and supported by camel caravans that dropped fuel and supplies at rendezvous points, Andrews covered vast sections of the Gobi with a speed and efficiency never previously attained in desert terrain. Even by today's standards, the geographical range and scientific achievements of these expeditions were impressive. Among the discoveries were rich fossil deposits that contained an enormous variety of extinct animals and plants, including the now-famous dinosaur eggs laid by a creature known as *Protoceratops*, which lived approximately 100,000,000 years ago. Excavations at numerous archeological sites yielded a wealth of artifacts relating to Paleolithic, Neolithic, and historical cultures. Extensive studies were made of Mongolia's geology, an immense area of the Gobi was accurately mapped for the first time, and thousands of zoological and botanical specimens were collected.

These accomplishments often involved serious risks. In addition to natural hazards posed by the Gobi's harsh environment, Andrews and his companions had to contend with Mongol bandits, Chinese civil wars, and severe political harassment. Eventually, they were even thrust into the forefront of Sino-American relations when the project became the target of antiforeign sentiment in China. Indeed, at the conclusion of the 1928 season the expedition's collections—eighty-seven crates of fossils from Inner Mongolia—were temporarily confiscated by a militant group called the Committee for the Preservation of Ancient Objects; and only after prolonged negotiations between the American Museum, the Department of State, and the Chinese government was Andrews permitted to return to the field in 1930, when the events described in the following article occurred.

Unfortunately, 1930 proved to be the final season for the Central Asiatic Expeditions; despite a concerted effort by Andrews to continue his explorations, subsequent political developments in eastern Asia made further work impossible. "We had barely scratched the surface of the Gobi's secrets," he later wrote; and in terms of paleontology at least, this statement was remarkably prophetic. Intensive research conducted since World War II by Russian, Mongol, and Polish scientists has established the Gobi as one of the world's most prolific fossil-hunting grounds—a fact Andrews had suspected as early as 1918 when he first began formulating plans for his historic venture. *Charles Gallenkamp*

*Research associate in Maya art at the Museum of New Mexico in Santa Fe, Charles Gallenkamp writes and lectures on the archeology, ethnology, and pre-Columbian art of the southwest United States, Mexico, and Central America. In 1976 he received a grant for research on the explorer Roy Chapman Andrews, and with the cooperation of the American Museum, he is currently writing* Desert Quest: Roy Chapman Andrews and the Central Asiatic Expeditions.

*APRIL 1931*

# THE FATE OF THE RASH PLATYBELODON

## A Prehistoric Death Trap Yields Its Spoils—Persistent Exploration by the Central Asiatic Expeditions in Eastern Mongolia at Last Reveals the Most Favorable Conditions Under Which Remains of Ancient Man Might Be Found

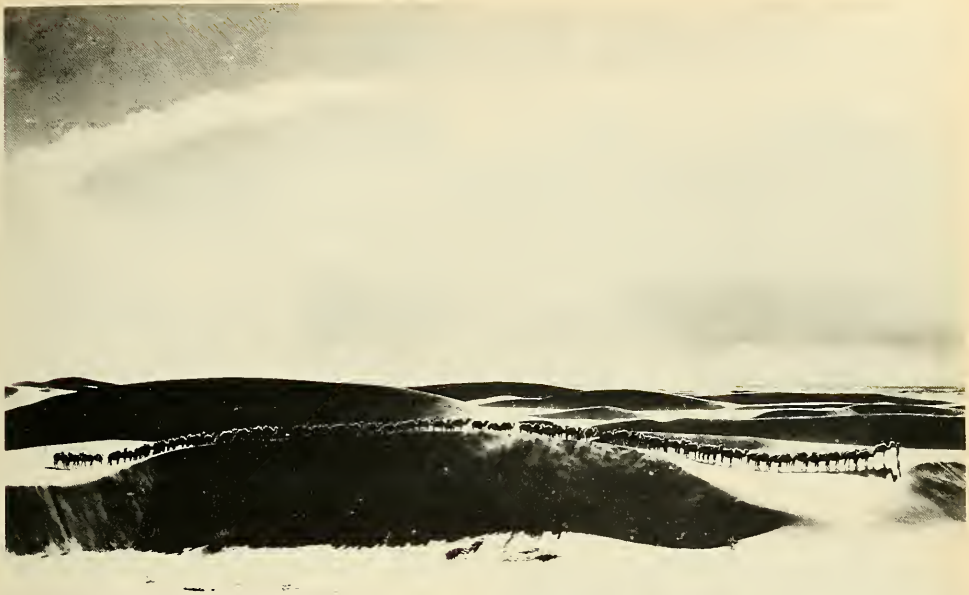
BY ROY CHAPMAN ANDREWS

I USED to believe that conducting explorations in the field was child's play in comparison to the difficulties of financing an expedition. But searching for the elusive dollar in the cañon of Wall Street is infinitely less nerve-racking than trying to steer a safe course for an expedition's ship between the rocks of Oriental diplomacy. Disturbed internal conditions and fluctuating politics present an almost unsurmountable wall to the foreign explorer. Weeks and often many months are required before permission can be obtained to go into the field.

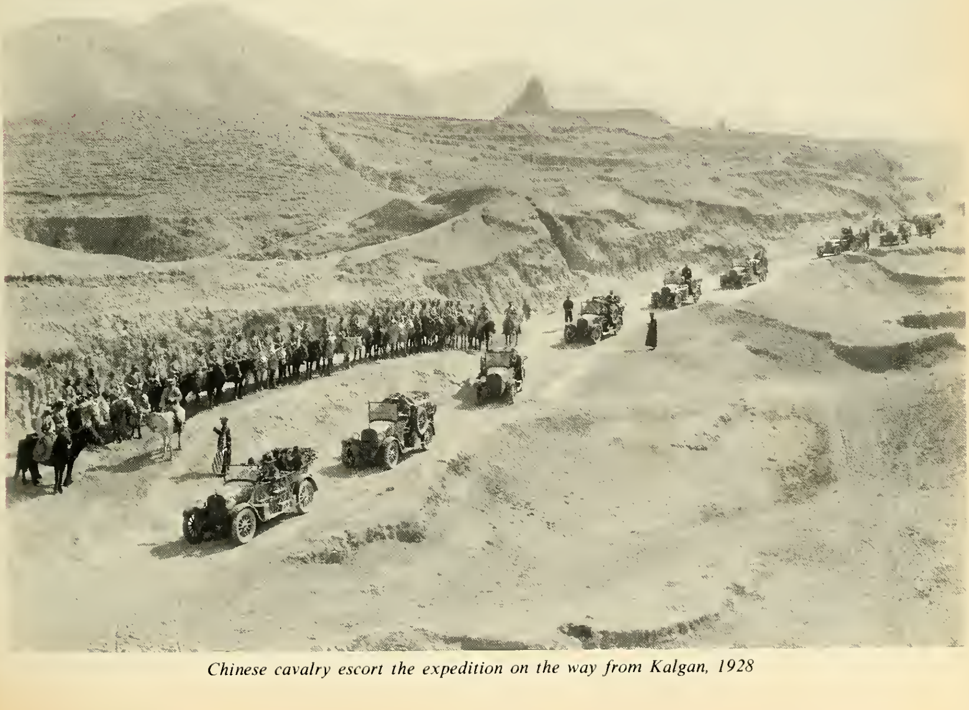
The Central Asiatic Expedition was fortunate in being able to continue its work in 1930, after a year's delay due to Chinese objections. Official sanction, however, was not finally obtained until the middle of May, and we could not leave for Mongolia until the 20th of that month—just five weeks later than in previous years.

A consultation decided us to send the camels to the place just south of the Outer Mongolian frontier, where we had discovered a jaw of the extraordinary shovel-tusked mastodon in the autumn of 1928. We had only partly explored that region and we hoped for great things in a more intensive study.

Some two or three million years ago in the Pleistocene



*The expedition's camel caravan crossing the Mongolian dunes, 1925*



*Chinese cavalry escort the expedition on the way from Kalgan, 1928*

*Wolf Camp, Mongolia, July 1930*

period, a great lake had occupied this part of Mongolia. The shore-line was clearly delineated by masses of fresh-water shells. It was probable that along the borders of this inland sea there had been quicksand bogs and muddy river bottoms in those far distant days when the shovel-tusked mastodon roamed the savannahs of Mongolia. Bogs and quicksands acted as traps then just as they do today. They are one of the most fruitful sources of well-preserved fossils and we began an intensive exploration of the lake shore.

We pitched our tents on a flat plain overlooking a great basin, cut and slashed by the knives of wind and frost and rain into a thousand gaping wounds. Behind us stretched a plateau which flowed away in great sweeping billows, a seemingly flat expanse. It was only when a horse or a running antelope disappeared suddenly from the eye that one could realize that the plain was not as flat as the top of a table. We knew from previous explorations that this was a dangerous place, because for many miles in every direction it was a waterless expanse. Mongols could not live there except in winter; it was inhabited only by antelopes, wolves, and desert birds. We named our camping place Wolf Camp, because, during two months' stay, we shot thirteen of these

*Platybelodon quarry five miles south of Wolf Camp, July 1930*

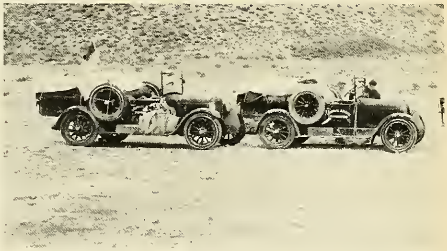
*Fossils laid out on the floor of the laboratory at the Peking headquarters, 1930*

marauders which preyed upon the sheep and goats of the Mongols, in a village grouped about a marshy pond eight miles away on the lowlands.

Just below the tents on a narrow promontory, we discovered many outcrops of bones. When the deposit was opened, the skulls, jaws, and skeletal parts of baby mastodons far out-numbered all other animals. Evidently this had been a bog near the shore of the lake. Mother shovel-tusked mastodons with their babies had come here to drink or feed. The mud was comparatively shallow and, although both the adults and young doubtless became mired, the mothers, because of their superior strength, were able to extricate themselves and sometimes get out their babies also. But others were not so fortunate and many of them had been left to die. The crowning specimen was the jaw and part of the skull of an unborn baby. It lay in the pelvic bones of an adult female, the only adult which we found in the deposit. Albert Thomson delivered the child with Walter Granger as consulting physician, while the rest of us in the clinic amused ourselves by calling them such insulting names as "palaeontological midwives."

The most spectacular discovery of the year was made six miles to the south of Wolf Camp by Père Teilhard de Chardin. In an amphitheater, marked by a shining dome of pure white marl, hundreds of fossils were exposed upon the surface but all in a very restricted locality. Granger and Thomson, with their assistants, opened the deposit. They found great numbers of shovel-tusked mastodon jaws, skulls, and bones lying in a heterogeneous mass like a heap of giant jack straws. For six weeks the men worked in this one spot, taking out the most priceless specimens day after day. I used to sit on the edge of the escarpment just above them, drifting in imagination back to those past days when the waters of a beautiful lake filled the enormous basin. Where we worked, there had been a bay on the edge of which was a deep well of soft sticky mud. Probably it was covered by three or four feet of water on which grew a luxuriant mass of tubers and succulent aquatic plants—the favorite food of the shovel-tusked mastodon. One of these gigantic beasts plowed its way slowly along the shore of the bay, dredging up masses of trailing vegetation in its great spoon-shaped jaw. Then with its trunk or mobile lips the beast delicately selected choice bits and pushed them far back into its huge mouth to be masticated by the molar teeth. The plants floating over the death trap of mud enticed the mastodon farther and farther into the water. Suddenly it found that it could not withdraw its feet. Struggling madly in the grip of the clinging mud, it sank lower and lower until the water covered its head and the last struggles were those of a drowning beast. The trap remained baited and still other mastodons were lured into the well of death. Their huge bodies sank upon those that had gone before, until the pit was choked with masses of decomposing flesh. Eventually the lake dried up, but the bones remained entombed until we came to open the grave on that brilliant day in 1930. Seventeen great spoon-shaped jaws were taken out of this single deposit. With those obtained from the "baby pit," the Museum has a superb age series representing almost every stage in growth from the unborn young to the adult bulls with jaws five and one-half feet long. This age series is only rivaled by that of the dino-

*JANUARY/FEBRUARY 1921*



## THE MOTOR TRUCK IN CENTRAL ASIA

By ROY CHAPMAN ANDREWS

I remember once when we were returning to Kalgan from Urga, the capital of Mongolia, we discovered that the oil of our motor had all leaked out of the cans. It was impossible to go much farther and we were debating what to do. As our car swung over the summit of a rise, we saw the white tent and grazing camels of an enormous caravan. Of course, Mongols would have mutton fat and why not use that for oil! The caravan leader assured us that he had fat in plenty and in ten minutes a great pot of it was warming over the fire.

We poured it into the motor and proceeded merrily on our way. But there was one serious obstacle to our enjoyment of that ride. We had had very little food for some time and were very hungry. When the engine began to warm, a most tantalizing odor of roast lamb arose from the car! Shortly, I even imagined that I could smell mint sauce.

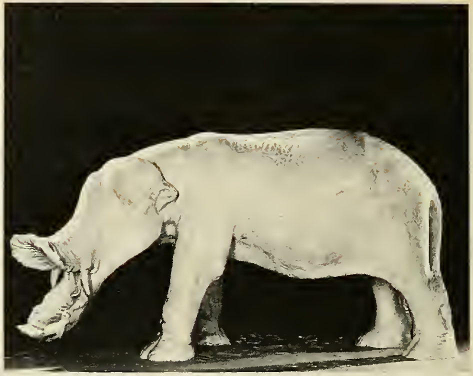
Once again we were without cup grease for the cars and Mrs. Andrews sacrificed all the cold cream and vaseline which she had prepared for a summer in the field. Mongol cheese, too, was substituted with good results.

saur *Protoceratops*, which demonstrates its growth from the egg up to the very old males.

The expedition spent two months at Wolf Camp, busy every moment on new and interesting discoveries. We might have remained all summer at this one site, for half a dozen other places were located which doubtless would have proved as rich as those tombs we had already opened. It is only in such deposits and in the river drift of ancient stream beds that we may hope to find the remains of primitive human types.

The summer's work indicated that this entire region was so rich and important that several years of additional work were highly desirable. Upon cabled instructions from President Osborn, I went to Peking on the 1st of September to open negotiations with the Committee for the Preservation of Ancient Objects. Mackenzie Young and I with one Chinese, Liu Shi-ku, drove down in two cars. During the summer the region had been remarkably clear of bandits, but it had been rumored that great quantities of opium were to be brought in from the west. This rich cargo had drawn bandits like flies to honey. A hundred and twenty miles from Kalgan the brother of one of our Mongols, Bato, told us that two Chinese cars had been robbed the night before and two men killed by thirty or forty brigands. He supposed that they were still there awaiting other victims and advised us not to go on. Mack and I, however, were heavily armed and decided to go through. Either the bandits had left or they were reluctant to attack us, because we reached Kalgan without a shot being fired. A week later, Mack returned accompanied only by Liu who drove the second car. Before he left Peking I had a strong presentiment that he would have trouble. It had been raining hard and the trail was very slippery. A hundred and ten miles from Kalgan a Mongol child ran out to the trail and told them that bandits had just stopped a caravan five miles away. Mack had either to turn back to Kalgan or else proceed and take his chance. He decided to go on. At a tiny mud-walled house in the bottom of a valley, he saw the brigands dressed in Chinese soldier uniforms robbing a caravan of carts. He drove on as fast as possible, but when his car was opposite the house, the robbers opened fire with Luger pistols from behind a mud wall. Slowing up a little, Mack took a snap shot at one man who was doing the best shooting. His bullet struck a stone, went to pieces, and took off part of the bandit's face. Another struck a second man in the shoulder. A little farther on were a dozen robbers standing by their horses. They opened fire with rifles as Mack went by and then started to mount their ponies. He killed a horse and this so discouraged the brigands that they galloped away. It had been a neat little fight and the bandits had been taught a pretty severe lesson. Fortunately, neither Mack nor Liu were hit.

*Excavating turtle skeletons near Camp Margetts, September 1930*

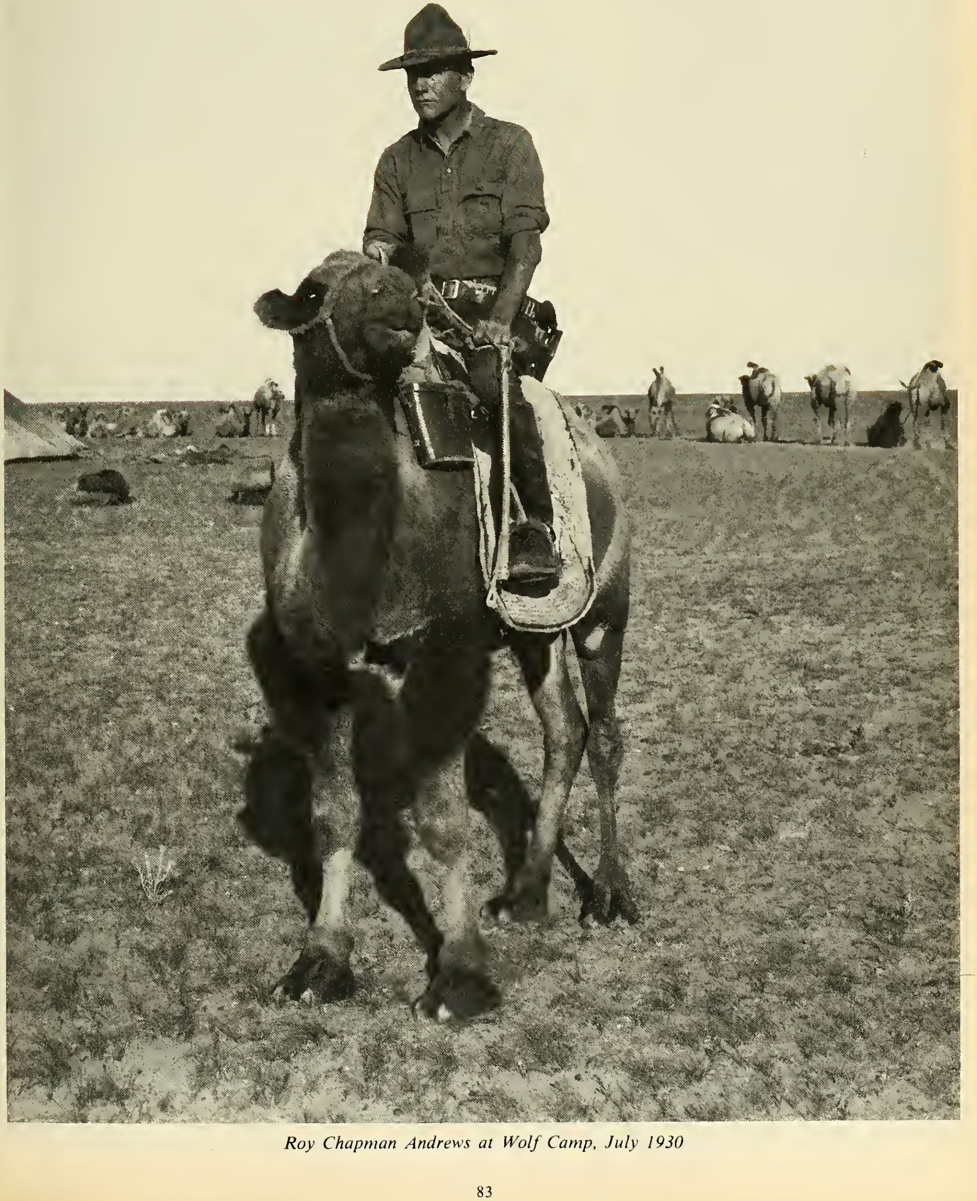


*Model of the Platybelodon, or shovel-tusked mastodon*

The whole Expedition returned a month later. Two days after they had reached Kalgan the entire region was taken over by bandits and all traffic on the plateau ceased. Had our people been delayed, the consequences would have been serious. It was only another evidence of the good luck which has been a constant factor in the success of the Central Asiatic Expeditions. The camels carrying our collections were met at a village thirty-four miles from Kalgan by Young and Liu and the fossils brought safely to Peking.

I cannot speak too highly of the courage and loyalty of every man, native and foreign, of the Expedition's staff. Through their splendid efforts the season's work netted the largest collection of any year in Mongolia. Ninety-one cases of fossils were obtained. We all feel that in scientific importance, as well as in bulk, this year's collections from Eastern Mongolia will equal if not surpass those of any previous season.

During all of the past years of our exploration, we have worked in central and western Mongolia where late Tertiary strata appear not to exist. Although we have opened a new volume in the history of the earth, the proper conditions under which human remains could be found were only discovered last year. It would be a scientific tragedy if lack of sympathy in China forces us to terminate our work.



*Roy Chapman Andrews at Wolf Camp, July 1930*

# MY LIFE AS A NATURALIST

BY THEODORE ROOSEVELT

I DON'T suppose that most men can tell why their minds are attracted to certain studies any more than why their tastes are attracted by certain fruits. Certainly, I can no more explain why I like "natural history" than why I like California canned peaches; nor why I do not care for that enormous brand of natural history which deals with invertebrates any more than why I do not care for brandied peaches. All I can say is that almost as soon as I began to read at all I began to like to read about the natural history of beasts and birds and the more formidable or interesting reptiles and fishes.

In the broader field, I sat at the feet of Darwin and Huxley; and studied the large volumes in which Marsh's and Leidy's palaeontological studies were embalmed, with a devotion that was usually attended by a dreary lack of reward—what would I not have given fifty years ago for a writer like Henry Fairfield Osborn, for some scientist who realized that intelligent laymen need a guide capable of building before their eyes the life that was, instead of merely cataloguing the fragments of the death that is.

I was a very nearsighted small boy, and did not even know that my eyes were not normal until I was fourteen; and so my field studies up to that period were even more worthless than those of the average boy who "collects" natural history specimens much as he collects stamps. I studied books industriously but nature only so far as could be compassed by a molelike vision; triumphs consisted in such things as bringing home and raising—by the aid of milk and a syringe—a family of very young gray squirrels, in fruitlessly endeavoring to tame an excessively unamiable woodchuck, and in making friends with a gentle, pretty, trustful white-footed mouse which reared her family in an empty flower pot. In order to attract my attention birds had to be as conspicuous as bobolinks or else had to perform feats such as I remember the barn swallows of my neighborhood once performed, when they assembled for the migration alongside our house and because of some freak of bewilderment swarmed in through the windows and clung helplessly to the curtains, the furniture, and even to our clothes.

Just before my fourteenth birthday my father—then a trustee of the American Museum of Natural History—started me on my rather mothlike career as a naturalist by giving me a pair of spectacles, a French pin-fire double-barreled shotgun—and lessons in stuffing birds, provided by Mr. John G. Bell, a professional taxidermist and collector who had accompanied Audubon on his trip to the then "Far West."

With my spectacles, my pin-fire gun, and my clumsy industry in skinning "specimens," I passed the winter of '72–73 in Egypt and Palestine, being then fourteen years old. My collections showed nothing but enthusiasm on my part. I got no bird of any unusual scientific value. My observations were as valueless as my collections save on just one small point; and this point is of interest only as showing, not my own power of observation, but the ability of good men to fail to observe or record the seemingly self-evident.

Two species of chats—Old World chats, of course, which have nothing in common with our queer warbler of the same name—were common along the edges of the desert. One species was a boldly pied black and white bird, the other was colored above much like the desert sand, so that when it crouched it was hard to see. I found that the strikingly conspicuous chat never tried to hide, was very much on the alert, and was sure to attract attention when a long way off; whereas the chat whose upper color harmonized with its surroundings usually sought to escape observation by crouching motionless. These facts were obvious even to a dull-sighted, not particularly observant boy; they were essential features in the comparison between and in the study of the life histories of the two birds. Yet neither of the two books in my possession dealing with Egyptian birds so much as hinted at them.

I think it was my observation of these, and a few similar facts, which prevented my yielding to the craze that fifteen or twenty years ago became an obsession with certain otherwise good men—the belief that all animals were protectively colored when in their natural surroundings. That this simply wasn't true was shown by a moment's thought of these two chats; no rational man could doubt that one was revealingly and the other concealingly colored; and each was an example of what was true in thousands of other cases. Moreover, the incident showed the only, and very mild, merit which I ever developed as a "faunal naturalist." I never grew to have keen powers of observation. But whatever I did see I saw truly, and I was fairly apt to understand what it meant.

After returning to this country and until I was halfway through college, I continued to observe and collect in the fashion of the ordinary boy who is interested in natural history. During the years when I "collected specimens" at Oyster Bay or in the north woods, my contributions to original research were of minimum worth. I lived in a region zoölogically so well known that the obvious facts had all been set forth already, and as I lacked the power to find out the things that were not ob-

*President Roosevelt with naturalist John Burroughs (left) in Yellowstone National Park, spring 1903*

*TR about to enter Yellowstone National Park, 1903*

*TR in Africa*

vious, my work merely paralleled the similar work of hundreds of other young collectors who had a very good time but who made no particular addition to the sum of human knowledge.

Among my boy friends who cared for ornithology was a fine and manly young fellow, Fred Osborn, the brother of Henry Fairfield Osborn. He was drowned, in his gallant youth, forty years ago; but he comes as vividly before my eyes now as if he were still alive. One cold and snowy winter I spent a day with him at his father's house at Garrison-on-the-Hudson. Numerous northern birds, which in our eyes were notable rarities, had come down with the hard weather. I spied a flock of crossbills in a pine, fired, and excitedly rushed forward. A twig caught my spectacles and snapped them I knew not where. But dim though my vision was, I could still make out the red birds lying on the snow; and to me they were treasures of such importance that I abandoned all thought of my glasses and began a nearsighted hunt for my quarry. By the time I had picked up the last crossbill I found that I had lost all trace of my glasses; my day's sport—or scientific endeavor, whatever you choose to call it—came to an abrupt end; and as a result of the lesson I never again in my life went out shooting, whether after sparrows or elephants, without a spare pair of spectacles in my pocket. After some ranch experiences I had my spectacle cases made of steel; and it was one of these steel spectacle cases which saved my life in after years when a man shot into me in Milwaukee.

While in Harvard I was among those who joined in forming the Nuttall Club, which I believe afterward became one of the parent sources of the American Ornithologists' Union.

The Harvard of that day was passing through a phase of biological study which was shaped by the belief that German university methods were the only ones worthy of copy, and by the proper admiration for the younger Agassiz, whose interest was mainly in the lower forms of marine life. Accordingly it was the accepted doctrine that a biologist—the word "naturalist" was eschewed as archaic—was to work toward the ideal of becoming a section-cutter of tissue, who spent his time studying this tissue, and low marine organisms, under the microscope. Such work was excellent; but it covered a very small part of the biological field; and not only was there no encouragement for the work of the field naturalist, the faunal naturalist, but this work was positively discouraged, and was treated as of negligible value. The effect of this attitude, common at that time to all our colleges, was detrimental to one very important side of natural history research. The admirable work of the microscopist had no attraction for me, nor was I fitted for it; I grew even more interested in other forms of work than in the work of a faunal naturalist; and I abandoned all thought of making the study of my science my life interest.

But I never lost a real interest in natural history; and I very keenly regret that at certain times I did not display this interest in more practical fashion. Thus, for the dozen years beginning with 1883, I spent much of my time on the Little Missouri, where big game was then plentiful. Most big game hunters never learn anything about the game except how to kill it; and most naturalists never observe it at all. Therefore a large amount of important and rather obvious facts remains unobserved or inaccurately observed until the species becomes extinct. But I vaguely supposed that the obvious facts were known; and I let most of the opportunities pass by. Even so, many of my observations of the bighorns, white goats, prong-bucks, deer, wapiti, and occasional observations on some of the other beasts, such as black-footed ferrets, were of value.

To illustrate what I mean as "obvious" facts which nevertheless are of real value I shall instance the cougar. In the winter of 1910 I made a cougar hunt with hounds spending about five weeks in the mountains of northwestern Colorado. At that time the cougar had been seemingly well known to hunters, settlers, naturalists, and novelists for more than a century; and yet it was actually impossible to get trustworthy testimony on such elementary points as, for instance, whether the male and female mated permanently, or at least until the young were reared (like foxes and wolves), and whether the animal caught its prey by rambling and stalking or, as was frequently asserted, by lying in wait on the branches of a tree. The facts I saw and observed during our five weeks' hunt in the snow needed only the simplest powers of observation and of deduction from observation.

In South America I made observations of a certain value on some of the strange creatures we met, but the trip was primarily one of exploration. In Africa, however, we really did some good work in natural history. Many of my observations were set forth in my book *African Game Trails;* and I have always felt that the book which Edmund Heller and I jointly wrote, the *Life Histories of African Game Animals,* was a serious and worth-while contribution to science. Here again, this contribution, so far as I was concerned, consisted chiefly in seeing, recording, and interpreting facts which were really obvious, but to which observers hitherto had been blind, or which they had misinterpreted partly because sportsmen seemed incapable of seeing anything except as a trophy, partly because stay-at-home systematists never saw anything at all except skins and skulls which enabled them to give Latin names to new "species" or "sub-species," partly because collectors had collected birds and beasts in precisely the spirit in which other collectors assembled postage stamps.

I do not think there is much else for me to say about my anything but important work as a naturalist. But perhaps I may say further that while my interest in natural history has added very little to my sum of achievement, it has added immeasurably to my sum of enjoyment in life.

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Theodore Roosevelt, president of the United States from 1901 to 1909, died less than one year following publication of this article. To perpetuate his life and work, the New York State Theodore Roosevelt Memorial Building was dedicated in 1936, and its administration delegated to the trustees of the American Museum of Natural History. The building, which serves as the Museum's principal entrance, bears murals and other decorations commemorating Roosevelt's character and accomplishments.

*TR at the Khartoum gymkhana*

# "TURNING KOGMOLLIK" FOR SCIENCE

Experiences of the Museum's Arctic Expedition

THERE could be no more simply told story of hardship, of high hopes made futile by storm and illness than that recorded in the latest letters from the Museum's Arctic Expedition. The past winter will long be remembered as the "hard times" winter by the two expedition leaders, Messrs. V. Stefánsson and R. M. Anderson, "turned Kogmollik" in the cause of science—"to turn Kogmollik" meaning to join forces with the Kogmollik Eskimos of the Mackenzie delta and eastward, dressing as they do and wandering with them to get a living from the country.

Any man who goes into the Arctics expects the possibility of having to face starvation, unless he takes a ship. It is impossible to carry with dog team or small boat enough to serve for more than a short journey; and if at the end of the journey, game proves scarce or wandering bands of Eskimos cannot be located, retreat from the difficult situation becomes problematic. In such straits Eskimos sometimes have to sacrifice their dogs; but unless worst comes to worst, they take such an adventure as a matter for joking and with whetted courage push on, perhaps in the face of a blizzard and through deep snows. The explanation of the Eskimo's cheerful view of the matter lies largely in his trust in the hospitality of his fellow Eskimos. For in Eskimo character there has evolved great unselfishness and in Eskimo tribal life a rare communism, passing strange and contradictory as it may seem that this should have taken place in a land of cold and privation, opposed to the selfishness and cruelty of most peoples of southern countries where there are physical comfort and plenty. A chief in the Arctics is not appointed or chosen, nor does he inherit his title. He attains it from a reputation for hospitality.

The Stefánsson-Anderson Expedition differs essentially from ordinary Arctic ventures in that whereas it is usual to carry along everything that the party is expected to need during its stay in the field, in this instance, little in the way of food, clothing or house materials was taken. This was the original plan, since the primary aim of the expedition is ethnological. How can a white man become familiar with the real life of primitive peoples, with their language, folk lore and songs, customs, beliefs and ambitions, except by living with them in their houses and as they do? Therefore, the leaders of the Arctic Expedition dress in Eskimo clothes, which weigh no more than a spring suit yet "allow one to sit comfortably on a block of snow, with back to the wind, fishing through a hole in the ice, the temperature being –50° Fahrenheit, and to feel the cold nowhere but on the face." They eat Eskimo food also, a great acquirement for a white man, and report that since the first month's difficulties they relish all—raw frozen fish, eaten as one would eat corn from the cob, boiled fish without salt, taken with the fingers, even the Eskimo delicacy of boiled fish heads, and, of course, seal oil, whale blubber and deer meat.

The Arctic Expedition left New York in May, 1908, to make a scientific study of little-known Eskimos, especially those tribes east of the Mackenzie River, and to obtain, of course, as much material as possible to illustrate Eskimo life and customs. Secondarily, it is to carry on a zoölogical survey, procuring collections of mammals, birds and fish, this work being in the hands of Dr. Anderson.

Although the desire was to go directly to the eastern Eskimo tribes, the final arrangements sent the expedition west to the Colville River area with the idea of returning eastward by whaling ship. The latter plan ingloriously miscarried owing to the fact that no whaling vessel visited the region during the whole season, the first time such a thing had occurred during the forty years since ships began to visit there regularly. Thus the expedition was forced to winter in the lower Colville region.

Now it happens that the Colville, which is very poor in game, is not the place one would choose in which to spend a winter. The year before both dogs and Eskimos had starved to death there and many families had moved out. But the winter proved less difficult than had been feared; spring came and the main energies of the summer of 1909 were spent in getting eastward, with much time lost waiting for whalers which never came. Finally Mr. Stefánsson succeeded in getting as far east as Cape Parry, near enough to the Coppermine River area for a dash there at the opening of the spring of 1910—if the intervening winter could be successfully passed. It is this winter in the Cape Parry district that has proved the "hard times" winter for the expedition, set forth in the narrative of recent letters.

We landed, Nat-ku-tji-ak, his wife Pan-ni-gáb-luk and I, August 31, by the stranded wreck of the steam whaler "Alexander," lost here in the summer of 1906, ten miles east of Cape Parry. Our first object was to find deer, as we were insufficiently clothed for the winter and had on hand provisions for about two months only. After hunting inland in vain two days, we decided to store most of our stuff in an old house built by some Eskimos who pillaged the "Alexander," then proceed to Langton Bay to look for deer.

As soon as possible we began edging southwest along the coast, but it was slow work. Paddling a big umiak is slow work under any condition for three people. A few days of southwest gales would be separated from a few more days of southwest gales by perhaps a half day of calm, but never a breath of fair or land wind. Unfortunately for us we happened to have with us a map of the coast. When on September 7 we came to a bight in the shoreline which corresponds

Adm. Robert E. Peary, the first man to reach the North Pole, called Vilhajalmur Stefansson "the last of the old school" of Arctic explorers; "the worker with the dog and the sledge."

Actually, the "old school" to which Stefansson belonged was that of the explorer as showman-celebrity. Unfortunately, polar wastes proved ill-suited grounds for testing media myths. The Norwegian explorer Roald Amundsen warned that "certain death awaits" anyone misled by Stefansson's talk of the "friendly Arctic."

Certain death awaited Stefansson's 1913–18 Arctic expedition. William Laird McKinley, the last survivor, recently published a detailed account of this tragic venture. The expedition was ill conceived and carelessly planned. The ships weren't properly modified. Their cargoes weren't sensibly divided. The pemmican lacked fat. The staff were untrained in Arctic survival. There was absolutely no leadership. With the main ship, *Karluk*, ice locked and endangered, Stefansson left to go hunting.

When he returned, his ship was gone. It drifted west with the ice, then sank. Most of its complement of twenty-five (including an Eskimo woman and two children) reached Wrangel Island. From there the captain and an Eskimo crossed 200 miles of ice to Siberia, then traveled 500 miles along the coast to East Cape, where they sought help. A relief party, six months later, found eleven dead. Eight froze. Two starved. One killed himself.

Stefansson, accepting no blame, wrote an inaccurate and uncharitable account of these events. To prove himself right, he organized another expedition: four men and an Eskimo girl were left on Wrangel with provisions for six months to last them a possible two years. Only the girl survived.

Yet Stefansson became, in the press, *the* name in Arctic exploration. No more. Those headlines are now forgotten. Who now remembers Stefansson's report of a race of "Blond Eskimos"? His tales of survival by ingenuity are questioned. He was a good hunter, but he lived off the people as much as off the land. On one occasion, when he wrote of self-sufficiency, a companion, in his diary, wrote of "two sleds heavily laden with 200 pounds of whale meat and 400 frozen fish . . . purchased from Arlook."

Stefansson was a likable man and undoubtedly brave. He was also a good writer. But while he entertained the public, a number of quiet scientists began to explore this last great unknown. They treated northern problems practically, taking no unnecessary chances. Their goal was the advancement of knowledge.

Surely the greatest among them was Knud Rasmussen, who traveled across Arctic America from Greeland to Siberia, without mishap. This part-Danish, part-Eskimo ethnologist combined field life with genius. Today the world knows the Eskimos through his books, not because the press proclaimed him, but because he recorded a world more wondrous than anything conceived by "news makers." *Edmund Carpenter*

*An authority on the art and culture of the Arctic, Edmund Carpenter teaches anthropology at the New School for Social Research and communications at New York University. His most recent article for Natural History was published in February 1980.*

excellently with one on the map into which the map makers show that a large river empties, we concluded we had reached this river, R. la Roncière. The formation of the coast simulated well the mouth of a large river. We all agreed that the river must have trees, or at least large willows, as all good-sized rivers do, which would mean game, and it seemed advisable to ascend it. The beach was covered with small spruce drift trees which promised well. I made an entry in my diary to the effect that "R. la Roncière" differed from most Arctic rivers in that the Lord had put it in the same place as had pleased the map makers.

We ascended and found, sure enough, a river—small, it is true, but we took it for one of the numerous delta channels of a large stream. We went for about five miles farther and came to a small lake. We know now that "R. la Roncière" does not exist. It took us two days of fair weather to get back to the open sea again, and we finally reached Langton Bay September 13.

At Langton Bay, Mr. Stefánsson and the Eskimos hunted with little success. This was unfortunate because all were short of deerskins. Each person in the Arctics needs at least six deerskins for clothes and three for bedding; in fact a total of nine skins is rather short allowance. Also, by the end of October, considerable anxiety began to be felt concerning the whereabouts of Dr. Anderson's party. Eventually Mr. Stefánsson and his Eskimo started out to find him, first building a log house with an open fireplace where the Eskimo woman could stay to protect a cache of twenty-two deer. Travelling was difficult but they reached the coast fifty miles west from Langton Bay by November 18. Here they found on the beach an old whale carcass, probably four years old, and spent a day getting a sled-load of blubber before proceeding. They had gone on only a day's journey when they were rejoiced to meet Dr. Anderson with his six Eskimo assistants. The whole party returned to the beach where the frozen whale was and spent the day getting another load of blubber and in talking over the situation.

Dr. Anderson had been traveling under unusual difficulties because he had a large party of assistants to make possible the transportation of supplies and collecting equipment. He says respecting this, "Turning Kogmollik has its disadvantages as well as its advantages. Alone I could shoot more game than I drew out of the pot and still have much leisure time for other work. There was certain work to be done, however, which I could not handle alone and diplomatic reasons compelled me to become a communist out and out. This meant a hand to mouth existence for a time with so many to be fed, some worry, and much hard work, but brought my boat and goods to the place where they had to be."

The matter of assistants in the Arctics is a large problem. To hire an Eskimo means that his family also must be fed and carried along with the expedition. Captain Roald Amundsen is of the opinion that outside of the scientific staff of an expedition Eskimos should best be depended on for all work, his chief reason being not the greater resistance of the Eskimo physically to northern hardships, although that is true also, but that the Eskimo does not get homesick and is not continually downhearted. The Eskimo's disposition is such that whether he be cold, hungry or in danger he seldom becomes dispirited or sulky. Commander Peary has always spoken in favor of Eskimo assistants and has always shown his personal preference in being accompanied by them on his dashes for the Pole. Mr. Stefánsson who had previously spent a year with the uncivilized Eskimo agreed with this opinion in favor of the Eskimo and the Museum's Arctic Expedition was planned accordingly. He reports, however, a wonderful change in the Eskimos as

*Breaking camp on the south side of Harrowby Bay, June 1910*

*Snow house with caribou skin roof, Prince Albert Sound, May 1911*

regards pay for services since he was at the Mackenzie delta in 1906. "Then they knew little about money and one could hardly pay for anything. He might make gifts, but pay was never asked and if offered needed explaining by the statement that white men always pay for food and work in their own country. So great is the change that now an Eskimo seldom remains permanently satisfied with the most liberal pay for services."

While the reunited divisions of the expedition worked getting a store of blubber, the leaders reviewed the past and carefully studied the future. One thing was certain, they must have the traps and ammunition that had been left perforce in the old house beside the wrecked "Alexander." Black and silver fox had recently been seen, black fox with a value from six hundred to a thousand dollars per skin. Besides there could be no more opportune time to get the things necessary for the Coppermine trip which would begin in the spring as soon as the sun came back. It was, therefore, decided that they should separate once again, and that Dr. Anderson with two Eskimos and ten dogs should go at once to the "Alexander." The day they separated was one of the worst of the year, –35° with a southwest blizzard. Going with the storm, Dr. Anderson could proceed; going in the face of the gale, Mr. Stefánsson's dogs refused to work, and his party was forced to wait till the storm abated. At last they started, six people with two days' provisions, and after fifteen days of struggle they got back to the log house where they had left the Eskimo woman in charge of the cache. Nothing could be more graphic than Mr. Stefánsson's description of these fifteen days:

> On the whole trip we killed five ptarmigan and not a single rabbit, though one of us hunted each bank all the way up. The sun was gone and so the daylight was meagre, besides it blew a blizzard every day. The whale tongue was very bad eating, it had little to it but dry fibres and was strongly impregnated with sea salts (other than NaCl). When we had finished this we were really better off for the stuff seemed to make us sick. We then ate sealskin, some deerskin we had along for sole leather and our snowshoe lashings, in fact every edible thing except clothes. Fortunately we had seal oil. With about a cupful of oil a day one does not feel in the least hungry but lazy, sleepy and weak. All of us found it a little difficult to take the oil straight. We soaked it up in tea leaves, deerskin with long hair on it and ptarmigan feathers.

Before they reached the end of these fifteen days some of the Eskimos were taken sick, and did not recover for weeks. These were indeed most discouraging times. Mr. Stefánsson was not able to go far from the camp because of the sick Eskimos, there were seven people and six dogs to feed, meaning a consumption of rather more than a deer per day, while there was no light but dim twilight for hunting, and every southeast wind brought fog, every southwest wind, a blizzard. To add to other causes for depression all were feeding wholly on lean meat in Arctic cold where health and spirits depend on the presence of fat in the food. Also it was at this time that the oil for lights gave out:

> At this time we had left only about a quart of oil, which was soon gone and we were without lamplight all the time the sun was away. This was especially inconvenient for the women, as sewing in the dark is difficult. There was more than once a whole week, too, when I made no entry in my diary because I could not see. One could write for about two hours at noon, but I was usually hunting at that time, always starting out before daybreak.
>
> In addition, we were getting badly worried over the non-arrival of Anderson and his party. They should have been home by Christmas. We were especially afraid that on the very day they left us in the blizzard they might have ventured too far off shore on the ice and have been carried with

it to sea. The sick Eskimos were growing despondent. I used to see deer almost every clear day (there was fog or blizzard two days out of three) but on the clear days it was so absolutely breathlessly calm that deer could hear you and you could hear them from a quarter to a half mile away. I therefore never got a shot at them. An Eskimo always looks upon such protracted ill luck as caused supernaturally. Taboos had been violated. They knew I had eaten deermeat the day I killed a wolf, but worse than that they knew of more than one case of my breaking the Sabbath. They were therefore certain they should never be able to get any deer. One day, however, I shot a fawn. This seemed to break the spell to the notion of the Eskimos.

In early January lack of food made some sort of a venture necessary, so a start was made for Langton Bay. Reaching the old house by the wreck of the "Alexander," they were astounded to find Dr. Anderson and one of his Eskimos there, recovering from pneumonia. Fortunately flour had been among the supplies left at the house or the men never could have lived through. Polar bears had broken in and devoured four boxes (500 lbs.) of whale blubber, two slabs of bacon, spilled a ten-gallon can of alcohol and "knocked things about generally"; but the flour they had not disturbed.

The letters report that in March all were "in fit condition, showing no serious after-effects," and that Mr. Stefánsson was expecting to start with his party during the first week in April for the Coppermine.

The expedition is planning to come out of the field soon, and great interest at the Museum attaches to the time when the full results of the work will be known. Making a zoölogical survey in the Arctics is a peculiarly difficult task due largely to problems of transportation of outfit and accumulating specimens; and the collections with duplicate series which the expedition reports will be of great scientific value. With the close of this expedition, Mr. Stefánsson will have five years' knowledge of the Eskimo. He has accomplished much in getting records of songs and short tales, working to ascertain definitely the presence and variations of certain folk tales throughout the tribes. He has complete lists of words used by the Shamans in ceremonials; and he has a large series of head measurements and many photographs. All results of the expedition will possess unusual value, representing as they do, work accomplished in spite of the almost insuperable obstacles set by the Arctic winter and by the necessity of "turning Kogmollik."

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Stefansson left Langton Bay on April 21, 1910, in search of unknown Eskimo groups of the Coronation Gulf–Victoria Island region. For a trip that he expected might last a year, he went with three Eskimos, six dogs, and enough food for two weeks—like his native companions, he had become adept at living off the land.

On May 13, on the ice of Dolphin and Union Strait, Stefansson's party came upon Eskimos who had never seen white men, who lived as their ancestors had lived since time immemorial. "Here were not remains of the Stone Age, but the Stone Age itself, men and women, very human, entirely friendly, who welcomed us to their homes and bade us stay."

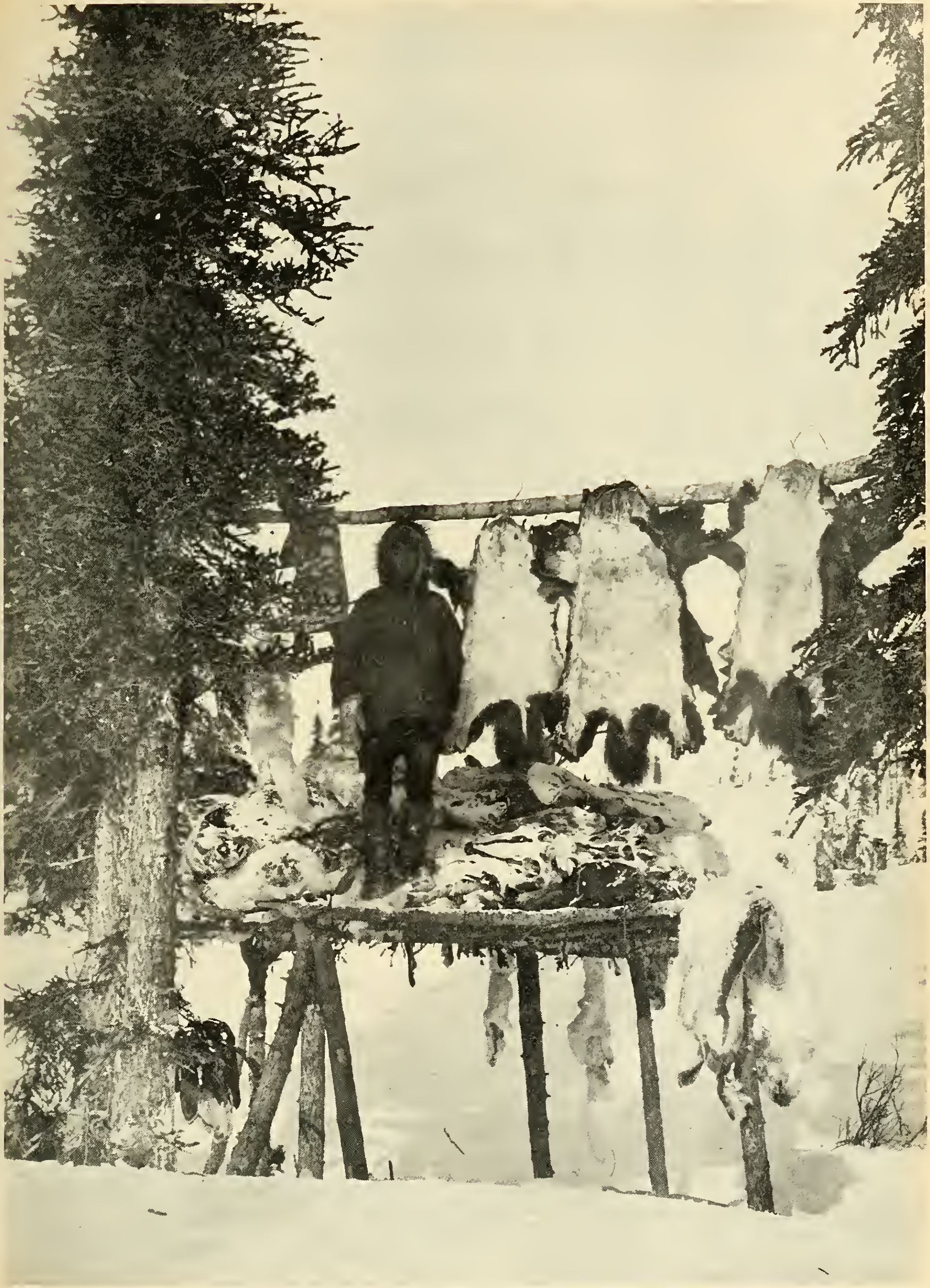
Even more startling, after crossing a portion of Victoria Island to Prince Albert Sound, Stefansson met Eskimos with a "light complexion [and] fair beards . . . I knew I was standing face to face with an important scientific discovery." He theorized that these people might be descendants of Greenland's "lost" Norse settlers. Upon his arrival in Seattle in the fall of 1912 he gave an interview in which, full of enthusiasm but somewhat injudiciously, he dwelt at length on his discovery of "blond Eskimos." The press loved the story, headlined it, embroidered it. Stefansson gained instant popular fame, but his scientific reputation was slightly tarnished. "The most palpable nonsense that ever came from the North," was the scathing comment of the famous explorer Roald Amundsen. The ensuing wrangle overshadowed to some extent the enormous achievements of the expedition, which with scant supplies, had spent more than four years in the Arctic and had returned with a wealth of scientific information and over 20,000 specimens.

On his way to the Arctic in 1908, along the Athabasca River, Stefansson noticed tar "which here and there trickled down the cut-banks of the river." Natural gas flared in the wilderness. To Stefansson it was "the torch of Science lighting the way of civilization and economic development to the realms of the unknown North." The Alberta tar sands are expected to yield 550,000 barrels of oil daily by 1985. Diamond Jenness, ethnologist on Stefansson's next, last, and greatest expedition (1913–1918) heard from natives on the Alaska coast about a "strange lake of 'pitch' . . . which poisoned any bird or animal that drank from it." Now a giant pipeline carries oil from this region across Alaska.

When Stefansson discovered the long-isolated Copper Eskimos, he found them to be a people who knew no illness and who were "more nearly satisfied with their condition" than anyone he had ever met, and he feared they would be "crushed by civilization's juggernaut." Within "ten years of our departure," wrote Diamond Jenness, "one-third of them had been swept away by influenza." And many of the survivors were suffering from advanced tuberculosis. Today, the land Stefansson knew so well is empty. Most Eskimos live in a few large settlements, in government-built three-bedroom houses. They watch television programs brought to them by satellite.

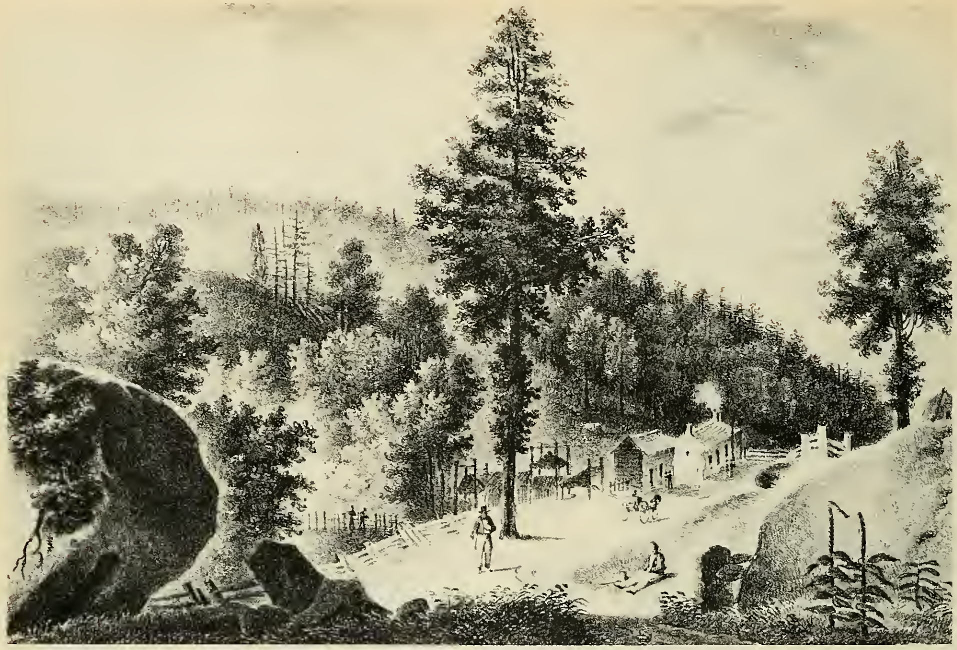
But the huge warehouses and the great community hall built by nineteenth-century whalers still stand. In the Beaufort Sea, which Stefansson crossed by dog team, giant dredges build artificial islands and drills probe for oil and gas. At Cape Parry, which he reached with so much trouble in August 1909, there is now a Distant Early Warning Line station. Ten miles away, the boilers of the whaler *Alexander*, wrecked in 1906, lie on the beach. And at Holman on Victoria Island, just north of Prince Albert Sound where Stefansson and Nat-ku-tji-ak first met the blond Eskimos, lives Jimmy Memogana. Now in his sixties, he is considered to be one of the best hunters and trappers in the settlement, just like his step-father, Nat-ku-tji-ak, whom Stefansson called "my mainstay" and "the best of all Eskimo hunters that I have known." *Fred Bruemmer*

*Fred Bruemmer is a writer-photographer with a special interest in the North. For the past seventeen years, he has spent about a half of each year studying the people and wildlife in the northern regions of the continent. His latest book is* Children of the North.

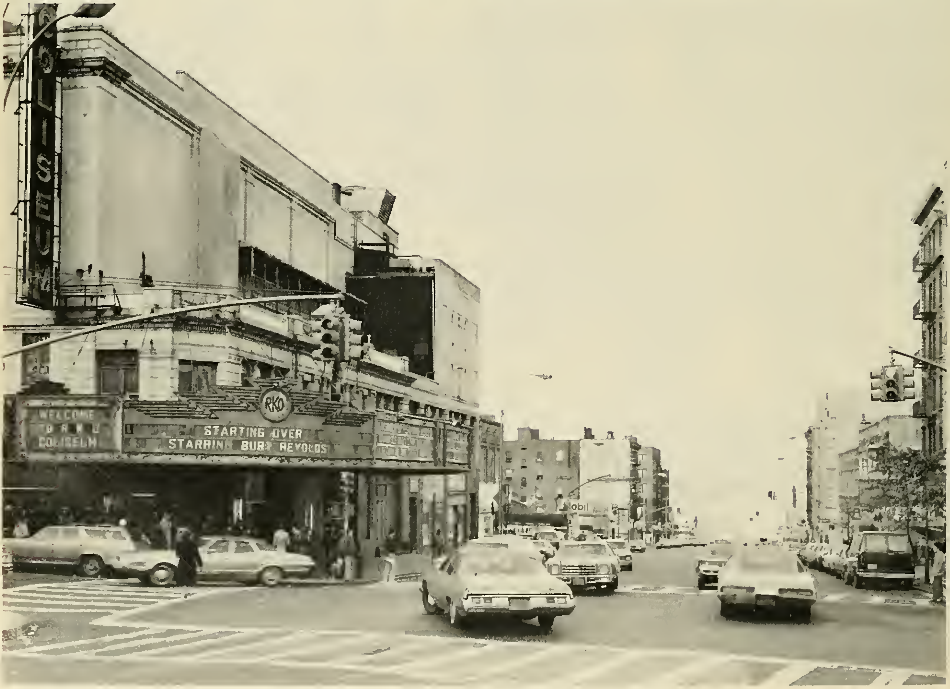


*Drying wolverine skins on a meat and skin rack, March 1910*

All pictures courtesy of the Museum of the City of New York unless otherwise noted.



*An 1825 lithograph shows the pre-Revolutionary Blue Bell Tavern, on Broadway, north of what is now 181st Street*


COLISEUM
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STARTING OVER
STARRING BURT REYNOLDS
Mobil

*Broadway at 181st Street, looking north, 1980*

Robert Bonano

*JANUARY/FEBRUARY 1920*

# A CHAPTER OF HISTORY AND NATURAL HISTORY IN OLD NEW YORK

### By GEORGE BIRD GRINNELL

THE wild life of New York City is for the most part transient; we see only birds of passage. During the migrations, native birds sometimes drop down into parks, back yards, or other open spaces, and are recognized by the passers-by as different from the English sparrow. People who know birds occasionally recognize thrushes, blackbirds, warblers, and even scarlet tanagers in the smaller parks; and sometimes other birds appear, as when a few years ago I saw a woodcock in Trinity Churchyard at Rector Street, and still longer ago, one in Union Square, which, when startled, flew straight east through 16th Street to alight no doubt in Stuyvesant Square.

The larger parks, like Central Park and Bronx and Prospect parks, permit birds to live under more or less natural conditions, and shelter, besides the birds, a few mammals—two or three species of squirrels, cottontail rabbits, and other lesser creatures. A few years ago a brood of wild black ducks was reared each year in Central Park, and in the New York Zoölogical Park various wild ducks are bred.

The presence of many people whose minds are occupied with other things than wild life tends to make safe not a few wild birds that spend the summers and rear their young in safety close to the city throngs. In the tidewater flats and marshes of Long Island City and of the outskirts of Jersey City, there are still no doubt—as there were a few years since—many places where blackbirds, coots, rails, shore birds, and other species not often seen, breed each year in safety. Duck hawks still rear their young on ledges of the Palisades and it may well enough be that near New York there are other breeding places of large birds.

My boyhood was spent in the country on the banks of the Hudson in Audubon Park. This had been the home of John James Audubon, and was then six or seven miles from the built-up portion of New York City. The only way of reaching it was by train from the Hudson River Railroad Station at Chambers Street, or by a stage which twice a day plied between Saul's Tavern, at 162d Street and Bloomingdale Road, and the corner of 36th Street and Broadway. There were few buildings north of 35th Street, and market gardens, which supplied vegetables to the city, began on the west side of the town near 40th Street, and extended far into the country. Ground for Central Park had just been set aside, but nothing had been done to transform it from a great piece of wild waste land.

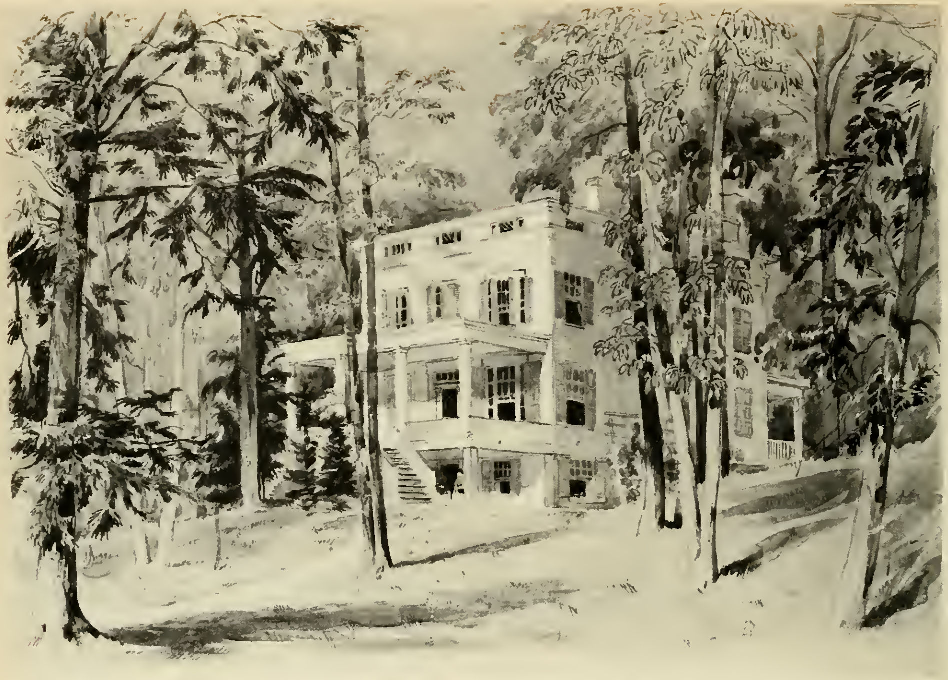
The conditions about Audubon Park were thus those of the country, and no doubt it was for this reason—because of its distance from the city and its freedom from people—that it had been chosen as a residence by the naturalist. In the woods and fields were found many of the birds that occur anywhere in the country of the eastern seacoast. During the migrations, ducks and geese were seen flying up and down the river, or over Manhattan Island; and a list of the birds would not, I suspect, have differed greatly from a bird list made anywhere else along the coast from Greenwich to Hackensack.

A notable feature of the wild life in this once remote region was the music of the birds, and chiefly the song of the wood thrush, great numbers of which nested among the hemlocks and white oaks and the undergrowth that stood there. Morning and evening each singing thrush, perched on the stout branch of giant white oak or hemlock—he seems to prefer that to a twig—poured forth his liquid notes, which, clear as a bell, rang out on the quiet air. Some people used to say that the notes of the thrushes of Audubon Park seemed to possess a clearer, more resonant quality than those of others of their kind, and rather sentimentally connected the sweetness of their song with the associations of the place.

The mammals were not many. There were three species of squirrels, of which the red squirrels were most abundant and the grays least so; while, owing to their nocturnal habits, the flying squirrels were seen only occasionally, although actually they were numerous. Trinity Cemetery was then enclosed by a high board fence, painted gray-blue. The horizontal boards were fastened to rough posts which were hidden by two vertical boards nailed on each side of the post and meeting outside it at an angle. In the high triangular chambers thus formed, there was often much space between the post and the boards, and here the flying squirrels used to make their nests. Some one of the boys at last discovered this habit, and after that most of the neighborhood lads maintained for a time a cage of captive flying squirrels, for the little animals were very abundant.

There were many muskrats on the rather extensive tidewater flats and coves of the Harlem River, and in winter, with Jack Audubon, I often went over to these flats to assist at the shooting of the muskrats.

At that time an arm of the Harlem River ran south through what are now the Polo Grounds, about to 145th



*John James Audubon's house stood between 155th and 156th Streets on the shore of the Hudson River*

Street, but east of this arm was a tongue of land which ran up toward McComb's Dam bridge. This is the present Eighth Avenue. Crossing the tidewater flat—in a general way about where the viaduct at 155th Street now runs, but really somewhat south of it—was a little footbridge, two planks wide, the planks resting on slender poles driven into the mud of the bottom. A footpath ran down the very steep hill near where 155th Street now is, and the little footbridge led from this path across to the solid land to the eastward. In this water there were many muskrats, and after ice had formed over it, they resorted to holes in the ice where we watched for them. They were not often killed, but occasionally one was recovered, and very often we believed we had killed one that had gotten away. Jack Audubon was often permitted by his father to carry his grandfather's gun, and he used it on his shooting excursions.

None of the modern streets or avenues was then open, and there were practically no dwellings along the Harlem River above Harlem Village. The steep, rocky bluff which overlooked the Harlem River, between about 150th Street and the High Bridge, was covered with a growth of tall, hardwood trees, chiefly oaks and chestnuts, and in these trees many crows bred as did also woodpeckers, blue jays, and smaller birds. Little screech owls often occupied the holes in trees abandoned by the golden-winged woodpeckers, and on more than one occasion a small boy thrusting his hand into the hole to feel for woodpecker eggs, found his fingers deeply pricked by the sharp talons of the little owls.

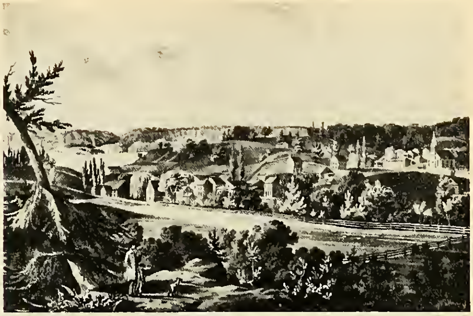
Between 158th Street, which was the northern boundary of Audubon Park, and Fort Washington, a mile to the north of that, was a stretch of woods interrupted in two places only by lanes leading from the main road along the ridge down to private dwellings near the river. In these woods were many rabbits, and I have always believed that on one occasion I started there a ruffed grouse.

At that time, and for many years afterward, there existed near the High Bridge—that is to say, just south of 175th Street, west of Tenth Avenue, and east of the so-called Bloomingdale Road, now perhaps Broadway-Eleventh Avenue—a considerable swamp which possessed a mysterious fascination for the boys of that time and place. Green herons bred there in considerable numbers; that is, we could always find a dozen nests. The birds were tame, for after the novelty of discovery had worn off, the boys seldom disturbed them and they soon became accustomed to the boys. Woodcock bred on the borders of this swamp, and were occasionally seen there and shot at in autumn. South of the swamp, which we called "the green heron woods," was a rather wide extent of pasture land, interrupted by occasional old stone walls and copses of undergrowth, to the point where Tenth Avenue and the present St. Nicholas Avenue cross—about 162d Street. After I had learned how to prepare bird skins, this large triangle was one of my favorite collecting grounds. It was varied in character and was frequented by a multitude of migrating small birds. For many years all this tract has been covered by tall apartment houses.

In this large triangle, which must have been three-quarters of a mile long, I recall but a single building—the old colonial stone structure known as the Cross Keys Tavern. There was a tradition that once Washington had slept there, and when I was a small boy, and perhaps much later, there still swung from a beam projecting out toward the road—west—a large weather-beaten sign on which were painted the two long keys crossing each other which gave the house its name. I cannot recall that it was ever used as a tavern.

During much of the winter the Hudson River was full of ice, on which eagles and crows were constantly seen perched or walking about, feeding no doubt on the refuse and the bodies of animals thrown into the stream farther north. There was a crow roost on a cedar-crowned knoll north—or east—of the Harlem River, but west of the New York, New Haven and Hartford Railroad and south of High Bridge. At daylight each morning the crows flew westward to the Hudson River, and on days when it was foggy or when it was snowing they often flew very low, even among the tree tops. The first crow I ever killed was shot just at dawn from one of the upper windows of the house as it flew over.

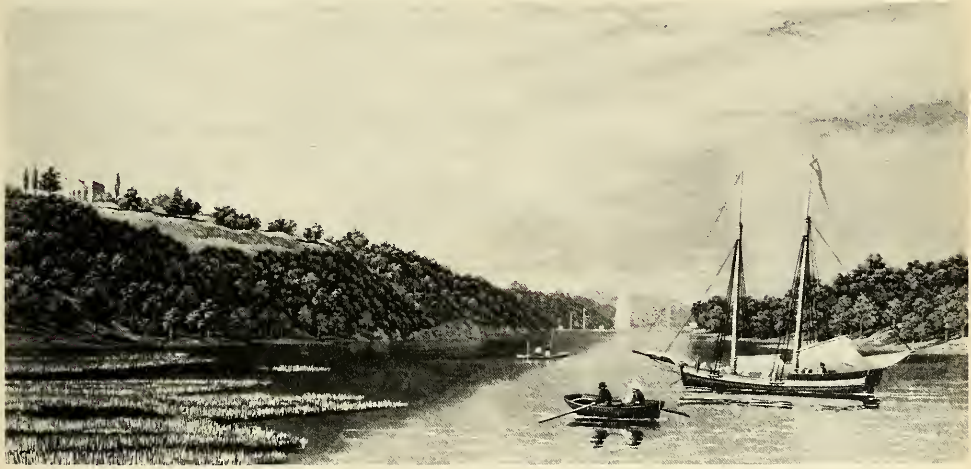
Sometimes the eagles from the river alighted in the large trees not far from the house, and at least on one occasion one of the birds dropped a fish which was picked up by the children.



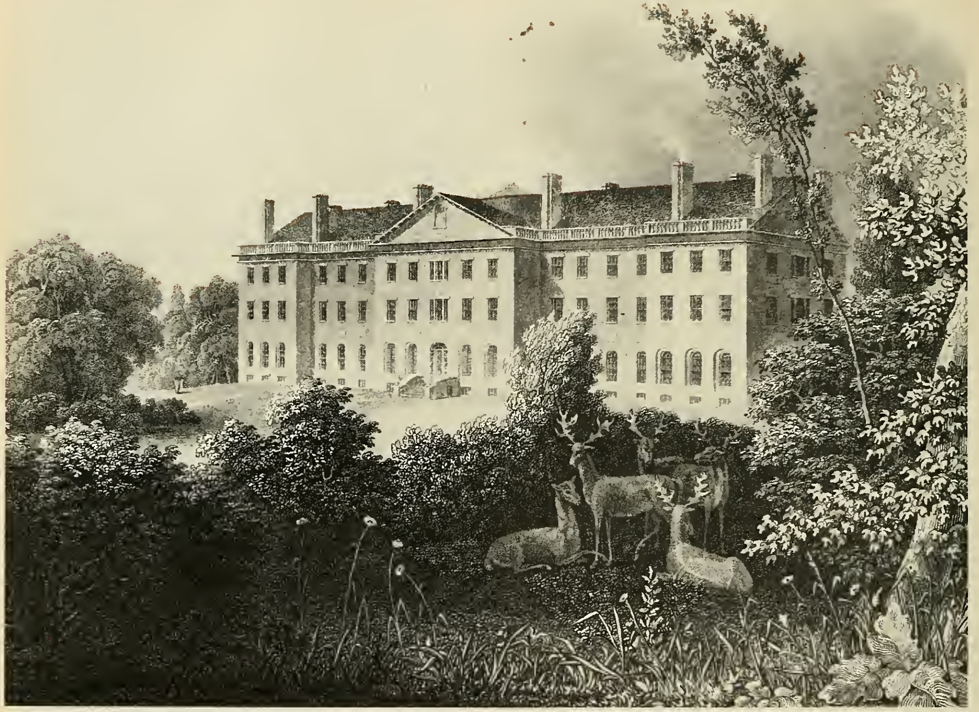
*The village of Manhattanville, drawn here in 1834, lay on the Hudson where the land dips down at 125th Street*

After the small boys of the time were old enough to carry guns, they devoted much of their time at certain seasons of the year to excursions after what they considered game. This game consisted chiefly of small birds, robins, woodpeckers, meadow larks, wild pigeons, and, at rare intervals, a rabbit, or even a duck. In the woods north toward Fort Washington were many dogwood trees, and in autumn when the berries were ripe, birds came here in great numbers to feed on the fruit. We used to sit near such trees and shoot the birds, which in due course were brought home and cooked. As we grew older we extended our wanderings farther afield, and worked our way north to Tubby Hook and to Dyckman's Meadows on the Harlem River where small sandpipers and small herons were often to be had, and at rare intervals a duck was found. Wood ducks and black ducks were the largest game the boys ever secured.

A longer excursion was up to Van Cortlandt Lake—the present Van Cortlandt Park, which we then called "Bronson's." From the lake a stream flowed out toward the Harlem River through a wide marshy meadow, largely overgrown with flags and high grass.



*The "View of the Jet at Harlem River" (ca. 1840) shows the Jumel mansion on the heights at left*



*Bloomingdale Asylum, erected in 1818–20, was north of present-day 116th Street, between Broadway and Amsterdam Avenue*

This, in autumn, was a resort for blackbirds, and here Wilson's snipe were sometimes started, but the small boys never killed them, nor any of the quail which were often seen, but which flew too fast for us.

One spring day I watched for a long time an osprey repairing its nest in a tall tree on a hill northeast of Van Cortlandt Lake. The nest seemed an old one, for it was very large, and the bird, as it swung over the ground in flight, was picking up bits of sod or of dry grass to use on the nest.

I had been to Van Cortlandt Lake long before these days, for when I was a very small boy two or three of the Audubon Park families had driven up to the lake on an all-day picnic. On this occasion my father, who was a great angler, had followed up a brook running into Van Cortlandt Lake and captured there an enormous trout, perhaps the only large fish in the brook. I should not dare to guess how long or how heavy this trout was, but I remember that it was regarded with astonishment and reverence by the other men of the party who had been less fortunate than its captor.

One autumn, soon after my first gun had been given to me, a woodcock made its appearance in our garden—near what would now be the corner of 157th Street and Broadway—and, until cold weather came, gave me a great deal of shooting. After I had learned that the bird was there I went out into the garden each morning before breakfast, found the bird, and shot at it. Later in the day I sometimes found it again and had another shot. I never hit the bird, but had much excitement in its pursuit.

Until as late as 1890 or 1895, quail and woodcock occasionally made their appearance in Audubon Park. The presence of the woodcock was always explainable, but I never was quite clear in my mind as to where quail came from.

Up to the time when that portion of Audubon Park east of Riverside Drive was swallowed up by the city—1909—two or three broods of little screech owls were reared each year in the great trees that grew in the place. From the piazza and the front windows of the house, in summer, the little owls might be seen almost any day dozing in the holes in the trees or on the branches. Now and then the children would find on the lawn a downy young owl that had fallen from a nest, and the work of returning the fledgling to a place of safety was always an exciting task for the children and for the parent birds.

The long-eared owl was occasionally seen on and near the place, and it was reported that the barred owl bred in the woods south of Fort Washington, although I knew nothing more than the report. In winter the snowy owl occasionally appeared, and the saw-whet owl was another winter species.

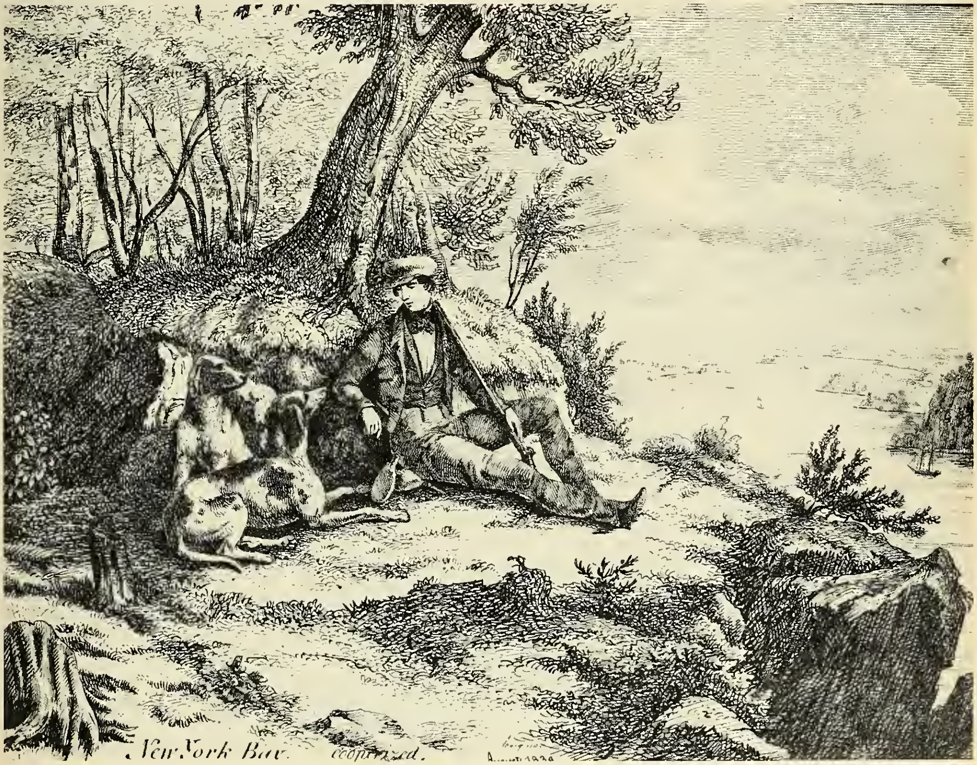
Up to 1909 golden-winged woodpeckers bred in some of the large trees on the place and it is quite possible that today some of these birds may breed in the Trinity Cemetery near by.

Such winter birds as the red and the white-winged crossbills and the snow bunting were occasionally seen, the crossbills as late as 1895–96, when a flock was observed one Sunday hard at work on the cones of a hemlock tree close to the house. A bird seen in winter, but not a winter bird, was a cardinal grosbeak, which made its appearance in February, 1867, on a small dogwood tree close to the house.

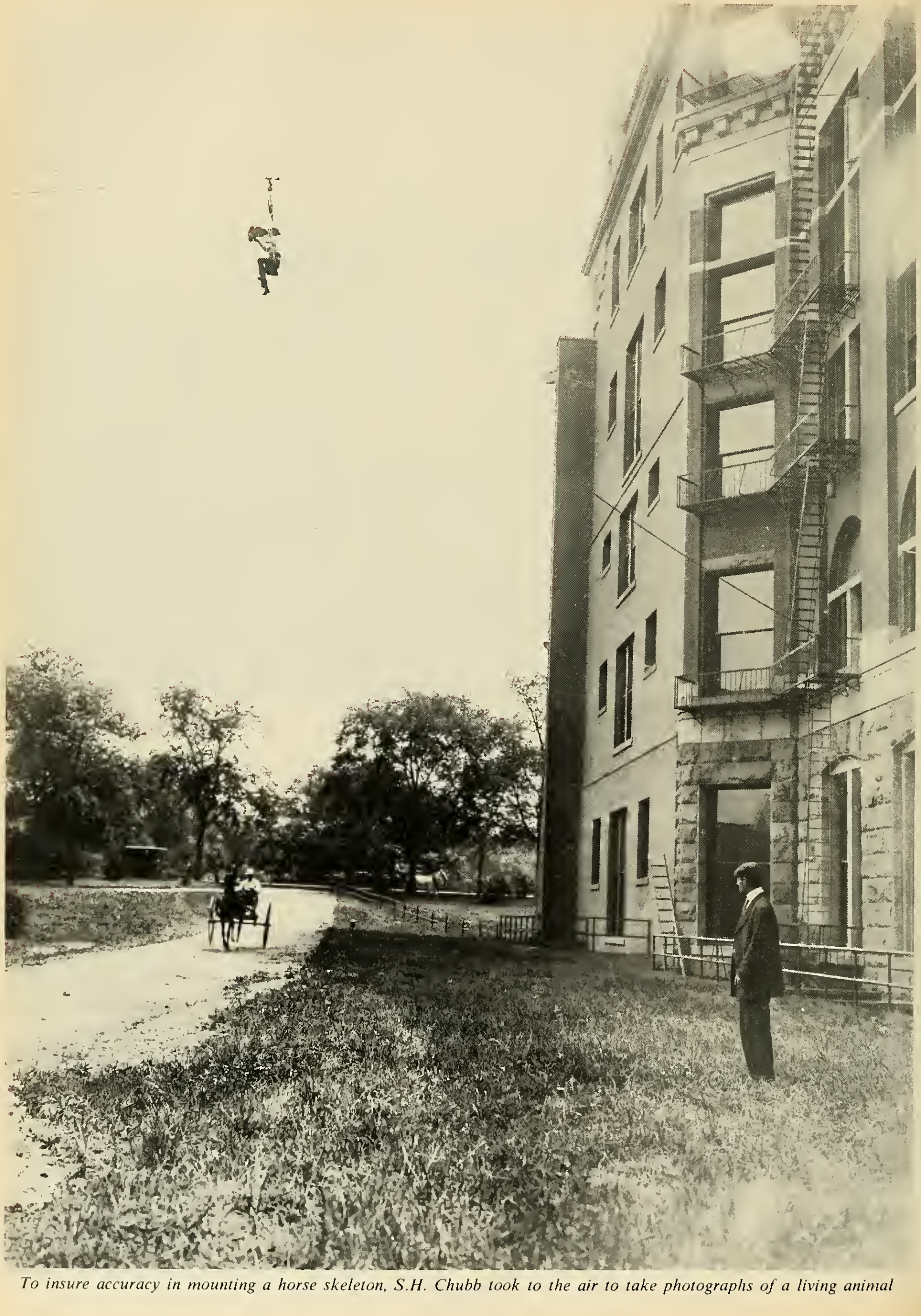
Wild passenger pigeons were seen each autumn at this point, and the boys used to have not a little excitement in shooting at them from the top of the house as they flew over north and south. It was discouraging work, for they really flew too fast to be hit, yet occasionally we got one.

New York has been spreading out and exterminating wild life for nearly three centuries. Thirty or forty years before 1860 the Lispenard Meadows afforded good snipe shooting, and in what are now Tompkins Square, Central Park, Broadway from about 46th Street to the North River, and Fifth Avenue at 32d Street, there was good woodcock and rabbit shooting. The growth from small population to great has taken place too often in American cities to cause us much surprise. Our larger wild life has for the most part disappeared, and population has increased so rapidly and territory has been so generally occupied that such changes will be less startling in the future than they are today.

As transportation facilities increased between the southern and the northern portions of Manhattan Island, population spread northward, and with a growing population, conditions became less favorable to the existence of wild life in upper New York. Broadway was opened in this region about 1874, I think, and somewhat later the elevated railway brought a host of people northward. Nevertheless, it was not until after 1900 that the wild birds became notably fewer. But, after the completion of the subway, the march northward of the tall buildings began, and the transformation was rapid.


New York Bay. cooperized.

*"New York Bay, Cooperized" is an 1839 sketch inspired by the romantic novels of James Fenimore Cooper*



*To insure accuracy in mounting a horse skeleton, S.H. Chubb took to the air to take photographs of a living animal*

# MOUNTING HORSE SKELETONS TO EXEMPLIFY DIFFERENT GAITS AND ACTIONS

A Glimpse Behind The Scenes At The American Museum

BY A. KATHERINE BERGER

TO convey to the spectator, through the mounted skeleton of a horse, some idea of the nicety of adjustment of every bone, and the positions assumed by it in relation to other bones during pulling, racing, trotting, and walking, is no easy task, and before accurate results are achieved, an amount of study, patience, and care is required little dreamed of by the casual observer.

For more than twenty years Mr. S.H. Chubb, of the department of comparative anatomy in the American Museum, has devoted all his attention to revolutionizing osteological preparation of Museum specimens. In the Museum collections is a nearly completed series of mounted skeletons of the Equidae in which Mr. Chubb is striving to represent with scientific accuracy and in lifelike pose every possible type of horse. There is a giant draft horse and, from practically the same stock, although representing another breed, the Shetland pony. The big horse has been developed through many generations for extreme size, whereas the Shetland pony has been reduced in size by man's selection and breeding. A heavy type of horse is shown in the position assumed when drawing a load. In contrast, there is the remarkable horse "Sysonby," known as one of America's most famous race horses, beautifully mounted to show the running gait characteristic of his kind. The pure-blood graceful Arabian, believed to be descended from an entirely distinct wild species, is represented in the skeleton of "Nimr"; and now the skeleton of "Lee Axworthy," the champion trotting stallion of the world (his record being 1.58¼), is to be added, practically completing the series of domestic horses.

To represent properly the changing curves of the spine of the race horse when he is running his fastest, Mr. Chubb conceived the idea of making photographic studies of a race horse's back in action. Accordingly an arrangement of ropes was prepared and fastened at one end to the roof of the American Museum and at the other to an adjacent tree. A swinging seat suspended from the rope and steadied by guy ropes afforded an unobstructed vantage point for the accommodation of Mr. Chubb and his camera. A race horse was borrowed for the occasion. Certain points of the animal's anatomy, previously determined upon by Mr. Chubb as best marking the constantly changing curves of the spine and the shifting of the muscles in action, were outlined with white patches which would be clearly visible in the photograph. Even the shadow of the horse cast by the sun at right angles was taken into consideration to help portray in profile the position of the horse's feet and body at the moment of exposure. All being ready, Mr. Chubb was hoisted fifty feet above the ground, and the horse was raced back and forth below him while he took photographic studies of the horse's back.

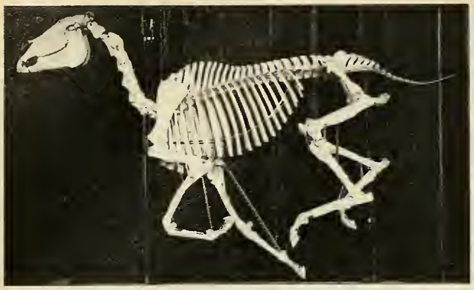
This new and unusual method of photography, also used in the case of the "Lee Axworthy" skeleton, resulted in a series of studies which proved of great value in establishing accuracy of bone adjustment when the skeleton of "Sysonby" was ready for mounting. These studies were supplemented by frequent visits to race courses where many observations were made of horses in action.

There is much to be done from the moment the skeleton is dissected to the time the bones are finally mounted. Sometimes these tasks are very time-consuming; eleven months were required to prepare the skeleton of "Sysonby" for exhibition.

The writer had an opportunity to witness a part of the preparation of the skeleton of the trotter "Lee Axworthy," listening the while as Mr. Chubb explained the process in progress at the time. Mr. Chubb was seated at a long table busily engaged in scraping from the sternum of the skeleton fragments of flesh and soft tissue that still adhered to the bone. Near him on the floor were several jars containing water in which were immersed various parts of the skeleton.

"When sufficiently decomposed the ligaments and tissues are removed and all that remains after dissecting is scraped away as clean as possible," he said. "If the surface of the bone dries too rapidly, it contracts and splits, while the inside is still wet. Slow drying is preferable and will prevent such injury by permitting the entire substance to dry evenly. The next step is to free the bones completely from all grease, that they may become spotlessly clean and pure in color before they are articulated."

Immersing the bones in benzine and exposing them while in this medium to daylight and sunshine for a number of weeks will accomplish the desired result most successfully. The benzine must be changed two, three, or possibly four times during this period, because it becomes saturated with the grease.

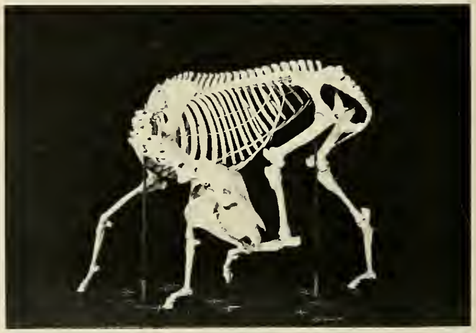


*The skeleton of the racehorse Sysonby, in position for permanent mounting*

"After the benzine process," said Mr. Chubb, "the bones are ready for mounting. First, I get a steel rod as nearly as possible fitting the opening and extending the length of the neural canal of the spinal column. This rod I must shape to the curve of the spine. Then the vertebrae are hung tentatively in place. Next, I gradually study the bones of the legs, which I fasten together temporarily so that any change can easily be made in the angle of the joints. The legs are suspended by looped cords passed over the heads of small screws, which are inserted in the bones at various points. The other ends of these cords are passed several times over horizontal rods above. To these free ends are attached small weights sufficiently heavy to prevent slipping, thus affording easy and convenient adjustment. Now comes the delicate task of getting the bones into the position which seems to suggest the action I have in mind, and seems to do it in a perfectly alive and satisfactory way. Getting the ribs in position is a long operation. I take a very small piece of pliable steel rod and fasten to it the several ribs, each by means of a rubber band. Then I study the little articulations. Finally, when they are all satisfactorily placed, I devise a permanent brace to fit the ribs and hold them enduringly in place. Every step, meanwhile, is checked up and corroborated by constant comparison with a great number of photographs.

"As I get the adjustment nearer and nearer perfection, I see errors in this part or that which were not obvious when the bones as a whole were out of position. It is simply a process of eliminating the errors until the whole becomes perfect. When all is right, I drill small holes where the bones come in contact with each other, and into these holes drive steel wires just tight enough to hold firmly but not tight enough to break the bone. Where there are many little bones, wires are driven in from opposite directions to bind all together as firmly as possible. These wires are driven down just a little below the surface of the bone, and the small holes which result from this operation are filled up later with plaster."

In studying the trotting modifications found in the skeleton of "Lee Axworthy," Mr. Chubb remarked that these might possibly be found in a race horse, but they were not evident in the skeleton of the race horse "Sysonby." On the front pastern (but not in the hind) of the skeleton of "Lee Axworthy" was a slight depression in the bone due to extreme movement of the pastern joint in the trotting action. Said Mr. Chubb, "I can imagine that this might become adaptive and prove of great advantage in that particular action, but we cannot say that it has gone far enough at present to be of great consequence."



*This mounted skeleton of a donkey relieving an itch was Chubb's last work*

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The skeletons of a horse and a man, painstakingly assembled to depict the man in the act of seizing the rearing animal's bridle, constitute the best-known example of Samuel Harmsted Chubb's art. The work serves today in graphic form as a symbol of the American Museum of Natural History. "It shows the superiority of intelligence over size," Chubb said of what was one of his favorite pieces.

Born in 1863, Chubb, the son of a doctor, became interested in skeletons as a young boy and would drag home specimens of dead animals for examination. His formal education ended after grade school, and at the age of sixteen, Chubb went to New York City, where he found work as a machinist. His first connection with the Museum came in 1892, when he showed samples of his osteological work to Henry Fairfield Osborn, who purchased the skeleton of a cat for $40. Several years later, Chubb left his job as a machinist to become a free-lance osteologist, and in 1901, he became formally associated with the Museum. Throughout his career, his training as a machinist enabled him to prepare the steel bases and mountings needed for the lifelike display of bones.

Chubb eventually became associate curator emeritus of comparative anatomy and remained active in his work until his death in 1949. In his nearly fifty years on the staff of the Museum, he worked on countless specimens, paying careful attention to the tiny vestigial bones that are of special interest to students of evolution. Only a fraction of these materials were ever put on display, and today, even the cases containing the skeleton of the racehorse Sysonby and other major pieces have been moved to storage. There are no plans to place these skeletons back on public view, but they will be distributed to the Museum's various departments and to other institutions to make them more available for research.

*NOVEMBER/DECEMBER 1928*

# SAMOAN CHILDREN AT WORK AND PLAY

Childhood and Youth. A Tropical and Idyllic Land to Which the Modern Psychological Problems of Civilized Youth Have Failed to Penetrate

BY MARGARET MEAD

WHEN anthropologists make trips to the far corners of the earth and search out the primitive peoples who live there, they add to our knowledge of the different ways of life under which human existence is possible, of the different kinds of demands which human beings can meet bravely and well.

It was to add to our store of this kind of information that I went to Taū, a little island in American Samoa, and spent nine months living among the few hundred South Sea Islanders who inhabit it. I went there to make a study of Samoan children and Samoan girlhood, to find out if the pains and pangs of growing up were as difficult in Samoa as in America.

This was no problem which could be solved in a flying trip. I could not just walk into the round, unwalled houses, with their high thatched roofs and pebbly floors, sit down on the mat which is always spread for strangers, and say to the guest-house mother who sat nursing one baby while a little older child tangled her half-finished mat, "Well, now, tell me, what are your children's names? How old are they? And Flower is the oldest? Does she take her responsibility seriously? Is she good and obedient? Is she bossy with the other children? Was she jealous when the new baby came?"—and then pass on to the next mother and ask her the same kind of questions, putting the answers all down on cards, to be counted and written up after I got back. If that mother, in her soft Polynesian language in which her children and I made the same mistakes, had answered my questions directly, I should not have understood her answers. For they would have run something like this:

"Names—well, the baby's name is Pandanus Nut, that's what we call it, or just Nut for short. But its name from its father's father's family is 'The One that Does Not Move,' and only yesterday my younger brother gave it his name of 'Lighted House,' so perhaps we will call it that now. And how old is he? Well, he was born after the second Palolo Fish Feast, and before my young cousin, Hibiscus, had her baby girl. He can't walk yet. The next one to the baby is called Bonito Fish. He is a boy. I don't know how old he is. And Flower, she is a girl, is the oldest of my children who are at home. There is that one, a boy, his name is White Stone, who lives with my mother, and the girl, her name is Jelly-fish, who lives with my first husband's sister in the next village. No, my first husband isn't dead! He's married to the sister of that woman with the banana leaf over her head, who is going down to the sea for water. I don't know what you mean by responsibility. Do you mean she has got common sense in her head enough to know that she mustn't play with her brother nor touch any of his things? She listens easily, not like my brother's children, who listen with difficulty to my brother's commands. Is she bossy? Of course she is bossy to all those in the family who are younger than she is, and listens to the wishes of all those who are older. And which new baby do you mean? My sister's baby, or my younger sister's baby, or my brother's wife's baby? But of course she was glad when all the babies were born."

Only after I had learned to speak the language well, and had spent long mornings sitting gossiping over a coconut or a plate of bananas, after I had learned to plait mats and blinds and helped the harassed homeless

*Samoan children in the shade of coconut palms*

*The heir apparent of an important chief*

people rebuild the village after a devastating hurricane, and had spent even more hours with the little girls themselves, searching for shells, weaving flower necklaces, coaxing land crabs with a low, sweet chant, or swimming in a hole in the reef, did I come to know enough about the Samoan way of life so that I could have understood those answers.

Samoan children's names change often, at the whim of any relative. As soon as they are old enough, they are allowed to choose new ones for themselves upon any occasion. And similarly they choose their own homes, living now with a grandmother, now with an uncle. Families are not made up of father and mother and children, but of some fifteen or twenty relatives among whom there is no oldest child, because a young aunt or cousin will be nearly of an age, among whom the same child is never "youngest" for long. And in these great households the mothers take little care of their children after the babies learn to crawl. The nurses are not young girls but toddling five-year-olds, who trundle about upon their hips babies that are too heavy to be lifted into their arms. Samoan children are not carefully disciplined and supervised until they are five or six, and then, properly trained, given some freedom. They are spoiled and pampered by their baby nurses until they are five, and then, if they are girls, they are turned into nurses themselves; if they are boys, they are turned over to the rough but thorough discipline of older boys. At ten years of age they are sturdy, well-behaved youngsters, although their bringing-up seems so strange to us.

Samoan parents do not hide anything from their children; they tell them no fairy tales about the birth of babies nor do they pack them off to a relative until after a funeral. They believe quite literally that children should be seen but not heard, should be present but make no comments, should learn the important facts of life from careful observation, not from random, groping experimentation. And the children grow up, acquainted with the rhythm of life and death, accepting life as simply and unrebelliously as do their parents.

Nor do Samoan parents think children should not work. The tiniest little staggerer has tasks to perform—to carry water, to borrow fire brands, to fetch leaves to stuff the pig. And these slighter tasks are laid aside for harder ones as soon as the child becomes strong enough or skilled enough. At the preparation for a feast to celebrate a visiting chief, a marriage, or a new canoe, the little children feel very serious and important, and go scurrying about the village, muttering, "There are very great complications in my household." Learning to run errands tactfully is one of the first lessons of childhood, and a child of nine will be trusted to take a valuable piece of bark cloth to barter for a pig.

This attitude toward children as little adults although lacking in experience and sometimes sadly devoid of common sense, makes for a different kind of play also. Samoan children have no dolls, no play houses, no tea sets, no toy boats. For dolls they have real babies; at six they are expected to sweep up the real house and pick all the scraps off the floor. Little boys anxious to become boatmen paddle about in real canoes within the safety of the lagoon. Embryonic eel fishermen hold the bait for their big brothers, but never play-act fishing in a pail, or catch a leaf and pretend it is an eel. Yet they have their games, playing at ball with square light balls made of pandanus, stringing necklaces of flowers, playing round games to merry songs of their own improvising in the dusk. And in all these they but imitate their elders, who follow a morning of work and an afternoon of sleep with an evening of dance and song.

Strangest of all to us is the Samoan opinion of precocious children. To be brighter than your age, to stand out conspicuously above other children, this is the sin for which a child is roundly scolded and sometimes whipped. So it is that the happiest children are those who like to be children, who put off responsibility, who do what is asked of them without aspiring to more grown-up tasks, those who answer in lazy content, "I am but young."

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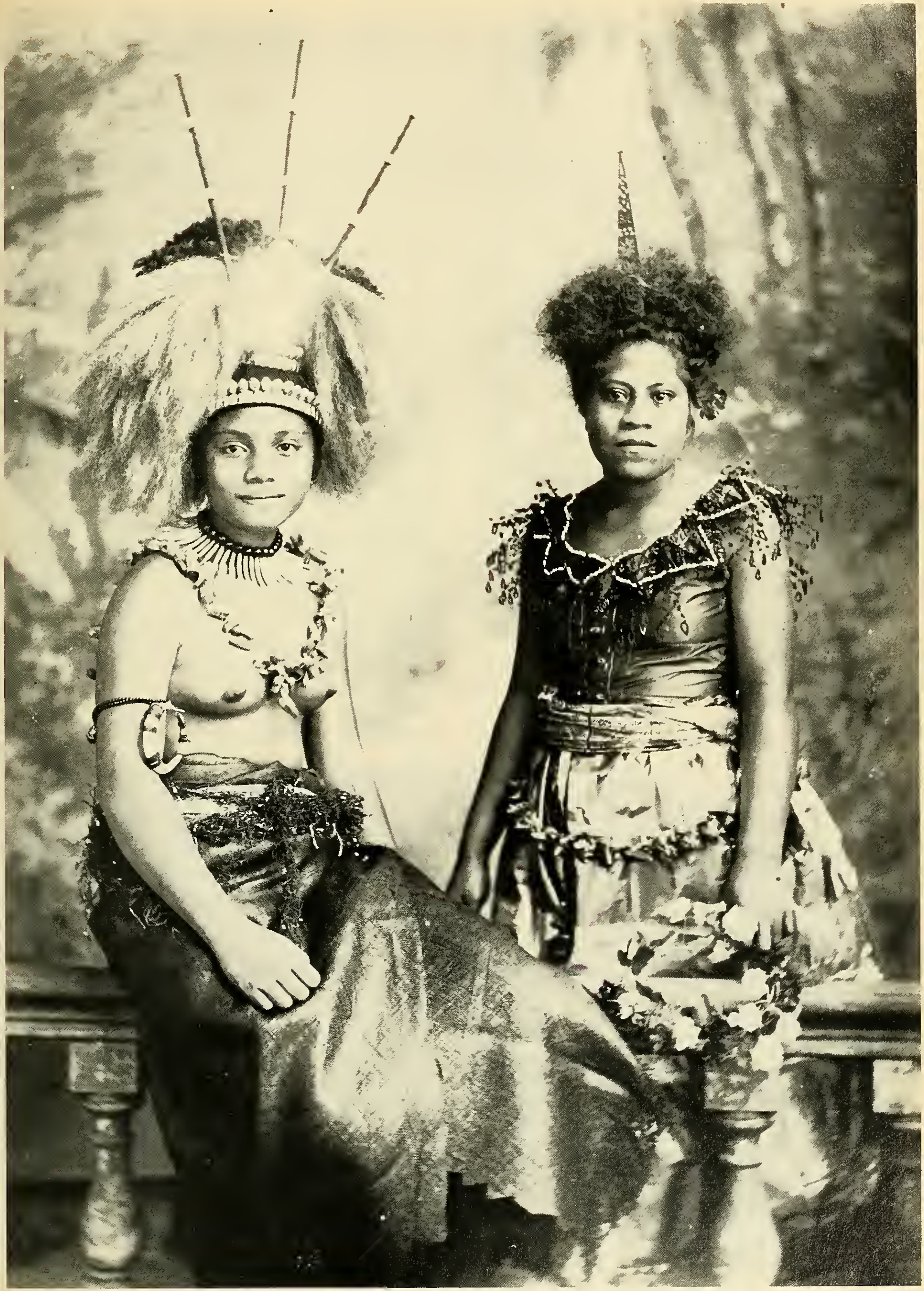
"Samoan Children at Work and Play," Margaret Mead's first article for *Natural History*, was based on her earliest field research. In the preface to the 1973 edition of her book *Coming of Age in Samoa*, she recalled, "I did not know then, could not know then, how extraordinarily persistent Samoan culture would prove, and how fifty years later the grace that I had attempted to record as something that was surely going to vanish would still be there." Curator emeritus of anthropology at the American Museum of Natural History, Margaret Mead died in New York City on November 15, 1978.



*Two village girls: The one at left has been honored with the title of* taupo

# CAN WE SAVE THE MAMMALS?

By

HENRY FAIRFIELD OSBORN AND HAROLD ELMER ANTHONY

The American Museum of Natural History is working hand in hand with the New York Zoölogical Society, with the Boone and Crockett Club, with the American Game Protective Association, with the American Bison Society, and the National Association of Audubon Societies, with the United States Biological Survey of Washington, with the National Parks Service of the United States Department of the Interior, with the American Society of Mammalogists, and with officers of the British, of the Indian, of the Australian, and of the British Colonial and Insular governments, to retard the inevitable CLOSE OF THE AGE OF MAMMALS. This title is not the cry of the alarmist; it is the expression of an actual and most melancholy fact, namely, that the glorious AGE OF MAMMALS is closing, that man will soon be alone amid the wreck of creation; that many of the races of man himself are passing under the inexorable law of extinction. The title "CAN WE SAVE THE MAMMALS?" is designed to strike a note of hope as to what yet may be accomplished toward salvaging for the future the little that remains of the wreck of the past.

FORTY years ago the birds of the world were in great danger of extinction, partly because of the ruthlessness of the man with the gun whom we will not designate a sportsman; partly because of the frivolous demands of the equally ruthless woman of fashion. As a glorious reward to the friends of the Audubon Societies in America and of the Plumage Bill Group and similar societies in Great Britain, the birds have been saved in English-speaking countries. Irresponsible destruction of game birds has been checked all over the North American continent and birds of all kinds are now multiplying. The destruction of birds of beauty and of song for the relentless purposes of fashion has been stopped so far as North America is concerned, and has recently been arrested all over the British Empire; it remains to check and stop it in the Latin countries. Not yet can it be said, however, that the birds of the world have been saved, because destruction of the superb pheasant family (Phasianidae) of Eastern Asia and of the still more brilliant birds of paradise (Paradiseidae) of New Guinea and adjacent islands is still proceeding with alarming rapidity.

The saving of the birds renders us hopeful that certain of the finest kinds of mammals, including those which are nearing extinction from natural causes, as well as many of the fur bearers that have been reduced in numbers through persistent persecution, can still be saved by three great movements along lines similar to those which have resulted in the preservation of the birds and of certain forests.

*First,* we may point out the alarming rate at which the mammals are now being slaughtered for commer-

*Siberian furs worth $100,000 on the wharf at Nome, Alaska, 1906*

Bettmann Archive

cial purposes and demonstrate that such devastating measures are ill-advised in that they are defeating their own ends. By pointing out the inevitable consequences of the rapid destruction of trees, conservationists were able to save some of the historic forests of Europe and of America. Those championing the right of survival of our game animals may in like manner refer to the fact that the unchecked destruction of any natural species, whether it be a *tree,* a *bird,* or a *mammal,* may mean an immediate monetary gain to a few individuals, but must mean ultimate monetary loss, not to mention *moral* and *spiritual* loss, to the entire community, while posterity is thereby robbed for all time of what should rightly be part of its heritage.

The *second* measure in this great conservation movement is again similar in character, whether it concerns trees, birds, or mammals: it is designed to prove that the final destruction of a species is against the general welfare, that it is unnecessary because stimulated by entirely *artificial* and not by real human needs. We cannot deny fur clothing to the Eskimo, a fur coat to the northern woodsman, the reasonable use of furs in civilized communities for dress and for ornament, any more than we can deny the reasonable use of trees for economic purposes, or of birds as a natural source of food supply. It is not the reasonable use of mammals which is bringing the great AGE OF MAMMALS to a close; it is the unnatural uses created by entirely artificial means, such as the wearing of furs purely as a means of display of wealth and for the purpose of gaining social position or standing.

Our *third,* and what may ultimately prove to be our most effective, measure in trying to save the mammals is that which has been applied to such advantage in the case of the birds, namely, creation among our school children of the sentiment of conservation, of the love of nature, of the appreciation of the wonder and beauty of mammalian life, of the realization of the great efforts which nature has put forth to produce the mammal kingdom, and of the enormous periods of time that have been required for its evolution; the sentiment, moreover, that mammals are the friends of man, that they are prototypes of our strength as well as our weakness, that they are among our best companions, that even some of the wildest of animals will become tame and companionable as soon as the gun of the market hunter and that of the sportsman are silenced.

These three watchwords of the mammal conservation movement are like the little flags known as guidons which direct lines of cavalry both in army maneuvers and in battle. Conservation is, in fact, partly a matter of skillful maneuvering following a long period of preliminary public education; it is also partly a matter of downright warfare. Some veterans, like the dean of American conservationists, Dr. W. T. Hornaday, always sound the battle cry; others, like the late lamented C. Gordon Hewitt, leader of the conservation forces in Canada, try to advance by the gentler methods of conciliation and of education. To save the mammals it is certainly necessary to marshal all our forces, both militant and persuasive, and to use all or any of these methods.

To enlist the coöperation of the readers of NATURAL HISTORY, let us present as our first line of attack some of the facts of the present period of slaughter which lead us to believe that unless there is a drastic change of action the AGE OF MAMMALS is coming to a close.

*Showroom of Rosensweig and Schwartz, furriers, 1920s*

Bettmann Archive

Nothing in the history of creation has paralleled the ravages of the fur and hide trade, which, with the bone fertilizer trade, now threatens the entire vertebrate kingdom. Furs are no longer worn primarily for protection in cold weather. Furs are now a fashion, just as feathers were forty years ago. The trade has passed almost entirely into the hands of people of Oriental and Asiatic origin. Millions of dollars are spent annually in advertising. Furs are worn in midsummer purely for personal adornment, or to make a display of wealth and luxury.

Some realization of the destruction now going on among the mammals is afforded by a glance at the statistics of our fur trade. After consulting a great number of fur-trade journals and reports, Mr. Anthony has compiled figures for the years 1919, 1920, and 1921, showing the large number of skins sold all over the United States at the fur auctions. The best of these journals is the *Fur Trade Review,* a large monthly publication given over to everything of interest to the fur dealer. In the *Fur Trade Review* one can find a list of all offerings at the different fur auctions, and it may be assumed that these figures are sufficiently authentic to be used in this article. In interpreting data of this nature, there are several features to be kept in mind. It is possible that the records of skins sold during any one year will not be a true record of the actual killing for the period in question, inasmuch as, during a time of high prices, skins may be brought out of storage to be marketed under favorable conditions. A large number of skins sold during

| POPULAR NAMES OF THE ORIGINAL FUR BEARERS WHICH HAVE BEEN SOLD DURING THE PAST CENTURY | SCIENTIFIC NAMES OF THE SAME FUR BEARERS | TOTAL NUMBERS BOUGHT OR SOLD BY THE FUR TRADE DURING THE YEARS 1919, 1920, 1921 |
|---|---|---|
| Beaver | *Castor canadensis* | 420,490 |
| Chinchilla | *Chinchilla lanigera* | 36,448 |
| Mink | *Putorius vison* | 2,540,971 |
| Fisher | *Martes pennanti* | 32,014 |
| Marten | *Mustela americana* | 309,808 |
| Ermine | *Putorius arcticus* | 3,492,412 |
| Sable | *Mustela zibellina* | 57,908 |
| Fur Seal | *Callorhinus alascanus* | 85,164 |
| Red Fox | *Vulpes fulvus* | 1,295,258 |
| Cross Fox | " " | 32,296 |
| Silver Fox | " " | 26,350 |
| Land Otter | *Lutra canadensis* | 111,059 |
| Sea Otter | *Latax lutris* | 76 |
|  | Total | 8,440,254 |

FUR BEARERS RECENTLY INTRODUCED BY THE FUR TRADE TO REPLACE THE DIMINISHING ORIGINAL FUR BEARERS

| POPULAR NAMES | POPULAR TRADE NAMES | SCIENTIFIC NAMES | TOTAL DURING 1919–21 |
|---|---|---|---|
| Muskrat | Hudson Seal | *Fiber zibethicus* | 14,109,288 |
| Nutria | Nutria | *Myocastor coypu* | 1,941,784 |
| Squirrel | Squirrel | *Sciurus vulgaris* | 14,858,316 |
| Marmot | When dyed, as Mink or Sable | *Marmota sp.* | 3,107,759 |
| White Hare | French Sable or Electric Seal | *Lepus sp.* | 3,713,036 |
| Mole | Mole | *Talpa sp.* | 23,801,905 |
| Stone Marten | Stone Marten | *Mustela foina* | 107,075 |
| Red Sable | Kolinsky | *Mustela sibirica* | 1,151,553 |
| Skunk | Skunk | *Mephitis sp.* | 6,895,674 |
| European Polecat | Fitch or Sable | *Mustela putorius* | 1,094,411 |
| Wolf | Wolf | *Canis sp.* | 1,094,502 |
| White Fox | White Fox | *Alopex lagopus* | 166,071 |
| Bobcat | Lynx | *Lynx rufus* | 191,799 |
| Raccoon | Raccoon or, dyed, as Lynx | *Procyon sp.* | 1,713,700 |
| American Opossum | Opossum | *Didelphys virginiana* | 9,787,742 |
| Australian Opossum | Opossum | *Phalanger sp.* | 4,265,621 |
| Ring-tailed Opossum | Opossum | *Pseudochirus and Phalanger sp.* | 1,321,625 |
| Koala[1] | Wombat | *Phascolarctus cinereus* | 208,677 |
| Wallaby | Kangaroo | *Macropus sp.* | 1,722,588 |
|  |  | Total | 91,253,126 |

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[1] Technically the Koala and the Wombat are different, but the Koala is classed as "Wombat" in fur circles.

Minnesota Historical Society

*Workshop of McKiffin, Driscoll, and Dorsey, manufacturers of fur hats, coats, and other apparel, ca. 1900*

a certain year may, therefore, have been collected over a period of several years. However, as we have had a few "boom" years, it is quite likely that all of such stored skins were brought out sometime ago and disposed of, so that the more recent figures probably indicate animals killed within a year of their sale. Furthermore, lots of skins may be sold at a spring auction and shipped to another part of the country to be resold in the fall, thus giving a duplication of numbers. However, omission of the winter sales of 1921 from this list more than offsets any duplication that may have occurred.

The discounted total of all skins sold for the three years in question reaches the alarmingly large figure of 107,689,927 skins. Moreover, this figure indicates only the slaughter of the animals which reached the market as skins. To show properly the actual slaughter that is taking place, one must allow for animals that were killed but not sent to the market because their skins were unprime, also for a considerable percentage of wounded animals which, although they escaped the hunter, were killed nevertheless, through his agency. A glance at some of the more noteworthy species sought by the fur trade that are indicated in the preceding table will show something of the scope and demands of this industry. Altogether the fur trade utilizes, at the very least, about one hundred twenty-five species, the exact number being difficult to determine because of the employment of trade names, which mean nothing to the zoölogist. Mr. Anthony has included in the table only thirty-two of the more important species out of the one hundred twenty-five species which are being destroyed.

A glance at the figures showing the number of skins of beaver (*Castor canadensis*) sold demonstrates what proper protection of a fur-bearing species may accomplish. Formerly trapped all over the American continent, beaver were brought almost to the verge of extermination, but for many years they have been protected and allowed to increase unmolested. As a result, during the period of the past three years, about 420,000 skins have come to the market.

The table indicates how relentless has been the pursuit of the muskrat (*Fiber zibethicus*), an animal which at one time brought such a low price at the sales that it was scarcely worth while to trap it; when muskrat fur came into fashion under the trade name of "Hudson seal," and the public demanded it, a systematic campaign of trapping began which brought muskrat skins to the market by the millions and now seriously threatens the very existence of this species. Squirrel (*Sciurus*) skins, most of which, we believe, have come from the Old World, make up a huge total of more than 14,000,000, and this is another example of a skin, formerly valued very slightly, that has come into prominence because of the demands of fashion. Skins of the insectivorous moles (*Talpa*) reach even a larger aggregate. The skin of the mole is so small that only since the passion for furs has become extreme has there been any incentive for men to molest this animal. Most of the skins disposed of at the sales listed on the table must have come from the Old World, and the mole, as anyone knows who has tried to trap it, is an exceedingly difficult animal to capture. More than 23,000,000 of these little animals were sacrificed to the insatiable demands of the fur trade. The mole, it may be claimed, is a small, insignificant species, and here and there among the list of fur bearers are other animals for which no economic value may be urged, but the presentation of this subject is intended to show the great destruction of mammal life, irrespective of species, and the possible desirability of exterminating any particular animal does not enter into the discussion.

The mink (*Putorius vison*), which was one of the first fur-bearers to be trapped in this country and which has remained a favorite for the past century, is an animal that apparently nowhere survives in very great numbers. However, since its skin has brought such a good price at auctions, our country has been combed over for mink, and the annual average yield of the last three years has risen to more than 500,000 skins. This is a very serious, if not fatal, tax upon the ability of the animal to maintain itself. The winter fur of the ermine (*Putorius arcticus*) has been worn from time immemorial and has been the fur of royalty. Today its use is much more general, witness the fact that no less than 4,400,000 skins of these little animals have come to the market during the three-year period. Before the recent craze for furs had begun, the skunk (*Mephitis*) enjoyed the immunity which nature intended him to have, and his skin brought such a low figure at the auctions that it scarcely paid anyone to run the risk of removing it. Now skunk fur commands such a high price that the trappers have covered all the American forests and plains area and more than 6,000,000 skins of this animal were disposed of at the auctions held from 1919 to 1921.

The raccoon (*Procyon*) is another animal the fur of which had but little value in early years; but to show how its status has changed, it will be necessary only to point out the total sales for the three year period, amounting to 1,700,000 skins. One of the furs most widely sold today was formerly worth but a few cents—we refer to the American or Virginia opossum (*Didelphys virginiana*). In those days there were few individuals other than boys who would give their time to skinning it, but since it has come into fashion, a vast number of market hunters have obtained the more than 9,700,000 skins subsequently placed on sale.

State Historical Society of Wisconsin

*Black fox pelts, worth $300 each, hang on the wall of a storage room where furs from northern Canada are sorted*

State Historical Society of Wisconsin

*Three trappers from the vicinity of Fall River, Wisconsin, pose with the skins of more than 500 muskrats, ca. 1910*

The average man has been led to suppose that wolves of the forests and plains have become almost extinct over most of the country. In the figures given for the wolf (*Canis lupus*), there are lumped together a great many species of coyotes and wolves, but, even so, the very large total of more than 1,000,000 skins is very significant of the great campaign that is being carried on against this animal, and at this rate it will not be very long before the wolf is extinct indeed. The red fox (*Vulpes fulvus*) has been such a prime favorite that great numbers of skins of this animal have come to the fur sales, and we understand that in some regions of the north the fox is virtually on the brink of extermination. More than 1,200,000 skins taken during the three-year period evidence a rate of destruction far greater than that which an animal like the fox can survive. On the other hand, the rarer foxes, the silver and the black, have been protected and reared in captivity, and we have learned upon good authority that most of the skins sold are those of ranch-reared animals. The fact that it was possible during the three-year period to place on the market the skins of more than 26,000 ranch-reared foxes furnishes a clew as to the proper methods for supplying the fur market.

The sea otter (*Latax lutris*), which furnishes the most beautiful of all furs, was represented on the fur counters by only seventy-six pelts—a sad commentary on the disappearance of this animal. Inasmuch as the sea otter is protected over most of its known range, some of the skins were doubtless taken illegally and unless some radical change for the better takes place, it will no longer be obtainable by the fur dealers. When the killing of the Alaskan fur seal (*Callorhinus alascanus*) had reached such serious proportions that the government found it necessary to intervene, and treaties were entered into establishing the right of this country to protect this animal, the northern herds were placed under supervision and the annual killing controlled by law. This regulation has worked out most satisfactorily, and a glance at the figures shows that over the three-year period more than 85,000 skins were sold—a very satisfactory total when one considers the high price commanded by the individual skin.

The figures just cited give a little insight into what

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*Pelting at Sterling Mink Farm, Lake Placid, New York*

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*Selling silver fox skins*

the fur trade is doing toward bringing about the close of the Age of Mammals. In a few years some of the mammals now sought by the trappers will be killed off to a point where they will not repay trapping, the numbers taken being insufficient to justify the expenditure of time and effort. Meanwhile, America has become the center of the fur trade. Before the war London was the world's fur market, but it now appears that the control has passed to the United States, and the great market of the present day is here.

The figures given out by the Fur Dressers and the Fur Dyers Association show that in New York City alone more than 80,000,000 skins were dressed and more than 97,000,000 were dyed by the members of this association during 1918, 1919, and 1920. Thus it would appear that the life of this industry throbs in our own country, and if any proscription is to be written, such as may serve to prolong the trade itself, the initiative should be taken by America. The more intelligent fur dealers realize that the wild animals are an asset to their industry, and judging by the editorials of the different journals, and the articles that appear, we believe that the majority of such fur dealers, if the matter were put to a vote, would encourage more humane methods of trapping and a more extended control over the wild animal supply. It would suit their own purposes better if animals could be taken only during that part of the winter when the furs are in their prime; the restriction of the hunting period to such a time of the year would be an important step toward the conservation of fur bearers. But as matters now stand, when fur prices begin to mount to such figures that a few skins represent many dollars, then in the out-of-way places where laws have but little significance at any season of the year, men go out and kill every fur bearer that they come upon, and run out their traps for whatever they may catch. Therefore, we believe that if some more intelligent and humane methods of checking this appalling slaughter are not soon inaugurated, the fur craze will have been the means not only of closing the Age of Mammals but of terminating a great industry.

From the standpoint of the naturalist, the Age of Mammals has long since closed as compared with the close of the Age of Reptiles, which occurred more than three million years ago. Extermination of the large mammals has been going on for a century; extermination of the small mammals has been extremely rapid in the last two decades. In North America alone mammals, broadly speaking, have disappeared within our life time. The present rate of destruction throughout the world from various causes is probably not less than fifty million a year, of which thirty million represents the demands of the fur trade. The bison is extinct in the United States except for the animals preserved in parks. Through the splendid efforts of the American Bison Society this noble quadruped is rapidly multiplying.

In Canada the wood bison is still holding its own and is, perhaps, slowly increasing. The elk, or wapiti, has disappeared from the greater part of its old range and is now found in its wild condition in only a few of our western states. On the danger line of actual extinction is our beautiful pronghorn antelope, the existence of which is seriously threatened, especially because of the great difficulty in supplying it with its natural conditions of life. Our other two large mammals, the Florida manatee, a wonderful "living fossil," survives in a restricted area and in limited numbers; the splendid elephant seal of the Pacific has been completely killed off except for a small colony in Guadeloupe Island. The sea otter has been very nearly exterminated along the American coasts. The American beaver is extinct over most of its ancient range but has increased in an astonishing manner in the areas where it is protected. Among the great mammals of the sea the California gray whale is nearly extinct. The right whale is in danger of extermination, and the disappearance of the bowhead whale is also threatened. The American Museum has thus far failed in its efforts to secure examples of this splendid species of whale before it disappears.

In many parts of the world, in Australia, in northern and southern Asia, and in North and South America, American Museum explorers are charged with the mission of securing single specimens of these fast-vanishing remnants of the AGE OF MAMMALS before it is too late. Many of the specimens which the Third Asiatic Expedition has secured will be among the last of their kind to find their way to the great museums of the world, because Mr. Roy Chapman Andrews, the leader of the expedition, has observed that their numbers are limited and that they are in near danger of extinction.

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In 1972, 1.7 million items manufactured from wildlife were imported into the United States. This figure had soared to 164.6 million by 1977, for a tremendous increase of 9,582 percent.

In 1973, 2,800 game trophies were imported into this country. Four years later, the figure was 19,300, an increase of 589 percent. Skin and hide imports rose from 910,000 to 1.15 million during this same period, up 26 percent.

In 1974, 161.3 million live animals were imported. In 1977, the number was 164.8 million.

According to Nicole Duplaix, director of Trade Records Analysis of Fauna and Flora, an office of the World Wildlife Fund-U.S., there is only one inspector from the U.S. Fish and Wildlife Service available at any one time at the Miami airport, a major port of entry. Incoming shipments of wildlife and animal products number hundreds per day.

*Furs of commercially raised foxes, Woods Cross, Utah, 1939*

Utah State Historical Society

BYRD ANTARCTIC EXPEDITION

# OVER THE SOUTH POLE BY AIR

Some Phases of the Polar Region Survey of 1928–30 Achieved with
All the Practicable Appurtenances of Modern Science

By REAR ADMIRAL RICHARD E. BYRD

As Told to Albert D. Barker

IN two hundred years of Antarctic exploration, the questions that have been raised about this great expanse of land buried beneath the earth's largest remnant of the Ice Age are as many as the blocks of ice in the vast, floating pack that encircles it. To seek solution of a few of these problems and to do the seeking with all the practicable appurtenances of modern science was the chief aim of the Byrd Antarctic Expedition, though, as was inevitable, the first flight by airplane ever made over the South Pole was bound to receive the public's principal notice.

Obviously I cannot in brief space chronicle the many events of an expedition that required three years of preparation; that left New York in August, 1928, and did not return until June, 1930; that was moved about 20,000 miles in two ships; that built its own village upon the ice and lived in it, usually buried by snow, 2300 miles from the nearest human dwelling; that for nearly fourteen months thrived in an almost lifeless land, in temperatures averaging about 16 degrees above zero in the warmest month and about 42 below in the coldest, did its work and returned without mishap.

To tell a fraction of this story is impossible, but I may well touch upon some of the ways in which this big undertaking differed from expeditions of the past and pointed to the modern methods that will greatly hasten the future scientific surveying of Antarctica.

Perhaps first comes to mind the extensive use made of the airplane by this expedition, which landed three on the ice barrier and flew them with entire success both before and after the winter night and in temperatures that were always low and often severe. The significance of the airplane in exploration like that done from Little America as a base is two-fold: It covers distance in minutes and hours instead of days and months, and it broadens the horizon five-fold. Hardly less important is a third related consideration. Using an aërial camera, the explorer now for the first time is able to bring back indisputable evidence of what is seen over wide areas.

There is no better illustration of these points than the South Pole flight. Amundsen, in his heroic "dash" to the Pole by dog team and afoot, required nearly 98 days to go and come. The "Floyd Bennett" took us there and back, with a minimum of physical hardship, in 19 hours. While Amundsen at the best was observing a terrain visible on either side for a distance of 8 miles only, our horizon averaged more than 50 miles. On level snow he commanded a panoramic view of 75 square miles; at 10,000 feet of altitude, we looked down on a world of more than 50,000 square miles, and at much lesser altitudes still immensely exceeded his range of vision.

Further, as this expanse of milky snow and ice and looming mountains unfolded, Capt. Ashley C. McKinley, third in command of the expedition and its aërial surveyor, was taking—instead of mental or pencil notes—an overlapping photographic record. The area covered in that one flight of less than a day's duration was about 150,000 square miles, the new and less known portions of which almost literally were brought back to New York on photographic negatives. In the various flights 150,000 square miles were surveyed by camera, an area which, if you are curious to visualize it, almost equals that of West Virginia, Ohio, Indiana, and Illinois combined.

The expedition made in all 23 flights and traveled by airplane about 7085 miles. Through use of this modern aid, the airplane, it covered an area of 500,000 square miles, of which 250,000 had no overlaps and 200,000 square miles, it is estimated, never before had been seen by man.

At the South Pole we were some 800 miles south of Little America, which, as I have said, was 2300 miles from any dwelling. An airline between our plane and New York would have measured nearly 10,000 miles. Below was nothing but a level plateau of dazzling snow—which as the camera records it, looks like a sheet of pebbled white paper. So we might, in all truth, have considered ourselves to be stark alone at the "end of the earth." Yet, in point of fact, my message that we were in the vicinity of the South Pole was almost instantly received at Little America, and quickly relayed to *The New York Times.*

News that under former methods of polar exploration might have reached "the outside" in a year or more, thus became the property of the civilized world within a few hours. With the radio, "the outside" has been moved right into camp and into the kit of every airplane and sledge party. No exploring or survey party left Little America on an extensive trip without the means of communicating with the base by radio. Indeed, on one flight an operator, listening in at the *Times* station in New York, caught the exchange of messages between plane and camp.

Shortly after we celebrated Christmas, 1928, by reaching the barrier ice in the Bay of Whales from our outside base at Dunedin, New Zealand, we had selected a permanent camp site on this great ice shelf a few miles inland, and hauled by dog sledge the 650 tons of supplies and material brought by the "City of New York" and the "Eleanor Bolling." The planes were one of our first concerns; as was the radio. Soon we had erected the three metal 60-foot towers and set up the mechanism of the Adolph S. Ochs station. Communication established, not a day elapsed whose events were not reported to the public. For the first time, a remote expedition was regularly breakfast-table news; for the first time, the members of such an expedition listened to radio broadcasts from a big city station and received word from their families; for the first time, business could be transacted between such an expedition and its headquarters 9000 miles away in an air line.

The radio, however, was not limited in its functions on this expedition to the practical uses that proved so immediately valuable. Many phases of radio reception and sending under the unusual conditions that were inherent in the location were studied and recorded—for instance, the varying phases of the local heaviside layer throughout the seasons.

Bettmann Archive

*Dog team of the Byrd Antarctic Expedition on trip from* LITTLE AMERICA *base camp*

Wide World Photos

*Byrd Expedition flagship,* City of New York, *returns to New York Bay*

But radio and airplane were only two of an array of modern aids to scientific investigation contained in the expedition's equipment, which was unusually complete. All the instruments requisite for geological, weather, and other studies were at hand and put to thorough use. The data records are being worked up and studied—a labor which will require months more.

Reporting officially by radio in June, 1929, to the Secretary of the Navy on our discovery of the Rockefeller Range of mountains, I said, "Aviation has discovered a new land, surveyed it and landed on it for scientific investigation." Prof. Laurence M. Gould, second in command of the expedition, its geologist and a leader in various scientific endeavors, went by plane to the base of this range, made extensive ground surveys with which to check the air survey, and with his party climbed the mountains to study the rock formations and take specimens from several of the 40 peaks and ridges, the highest 2075 feet.

Next season, Doctor Gould, using sledge teams—and let me say that the sledge dog, despite advances in science, is still indispensable in the Antarctic—laid a line of food and supply bases to the foot of the Queen Maude Range, and made a thorough geological study of the mountains and other formations at that point. Doctor Gould on this trip found sandstone and carbonaceous material, though his earlier findings had been mainly confined to granite.

For nine months the expedition made continuous photographic records of the magnetic elements, supplemented by absolute measurements with instruments. This work, done under severe conditions in snow and canvas houses where the temperature averaged 20 degrees below zero, showed greatly disturbed magnetic conditions. The observations covered the maximum of a sun spot cycle of considerable importance. A very complete part of the magnetic study was the record—as to types, intensity, direction, and color movement—kept of the auroras, which occurred on 90 per cent of clear nights.

As the Antarctic is one of the greatest birthplaces of "weather," we had the equipment of a first order Government weather observation station in charge of William C. Haines, meteorologist, but carried our studies also into channels not usually entered. Hourly, day and night, we took a systematic record of barometric pressure, temperature, cloudiness and precipitation, wind direction and velocity, humidity, visibility, and other phenomena. With kites and pilot balloons we made investigations of the upper air, reaching in these soundings altitudes of more than 30,000 feet. To obtain wind velocities and directions at various altitudes we made about 400 pilot balloon observations. These were of immediate use in determining the advisability of making flights, but their significance is far greater, for they in all probability will throw most valuable light upon atmospheric circulation in high southern latitudes. An interesting 40-day continuous record, taken during the last of our stay, provides in detail temperature, pressure and humidity at various levels.

Living upon a great ice shelf, we of course were curious as to how far below us was the solid land. Soundings with a sonic depth finder in the Bay of Whales close to Little America gave a depth of about 1600 feet, others to the south and east between 900 and 1000 feet. Other hydrographic work included study of sea life, and depositing message bottles, the recovery of which may some day add to our knowledge of Antarctic currents.

In addition to the meteorological temperature records, the expedition came away with data on the temperature of the ice barrier itself in relation to its physical makeup. Readings below the surface, checked against air temperatures and heat of sun, showed many interesting changes with the varying of the seasons. These records were made in snow tunnels, snow huts, crevasses, and at other subsurface locations where sun and air penetration might be expected to have an effect, or the extent of conductivity of the snow might be checked. Conditions at Little America gave splendid opportunity to measure the dust content of the air, which was determined to be about one half that found over the Pacific Ocean.

With the uniformly low air temperatures—almost never above the freezing point—it is rather surprising to examine figures obtained by our black bulb thermometer, insulated to register the amount of heat radiated by the sun, and find that it went as high as 115 degrees Fahrenheit above zero. A rule of thumb indication of the power that can be exerted by the sun in this bleak land was given by a black tarpaulin fifteen feet square, which sank nine inches into the snow in two sunny days.

Whenever I discuss with strangers the discovery of new territory by the Byrd Antarctic Expedition, I brace myself for the inevitable inquiry, "What use is it, now that you have found it?" Always I reply that whatever man finds, he finds a use for. This application of new knowledge to human needs or wants may require a short time, or it may require a century or more—but it inevitably comes.

Flying over the South Pole has become something of a commonplace. In the late 1970s, Air New Zealand began sightseeing flights from Auckland and Qantas began flights from Sydney. Senator Harry F. Byrd, Jr., of Virginia, a nephew of the Admiral, was scheduled to fly over the pole last November 28 with geologist Laurence M. Gould, who was second in command on the original Byrd Expedition, to celebrate the fiftieth anniversary of the Admiral's South Pole flight. The crash of an Air New Zealand plane that day on Mount Erebus in Antarctica caused a 24-hour postponement of the senator's flight.

AP

*Admiral Byrd rides up lower Broadway in ticker tape parade*

# THE TROUBLESOME NOTION OF EVOLUTION

At the start of this century, when *Natural History* began publishing, the *Origin of Species* had been in print for forty years. But the idea of evolution was still a controversial one.

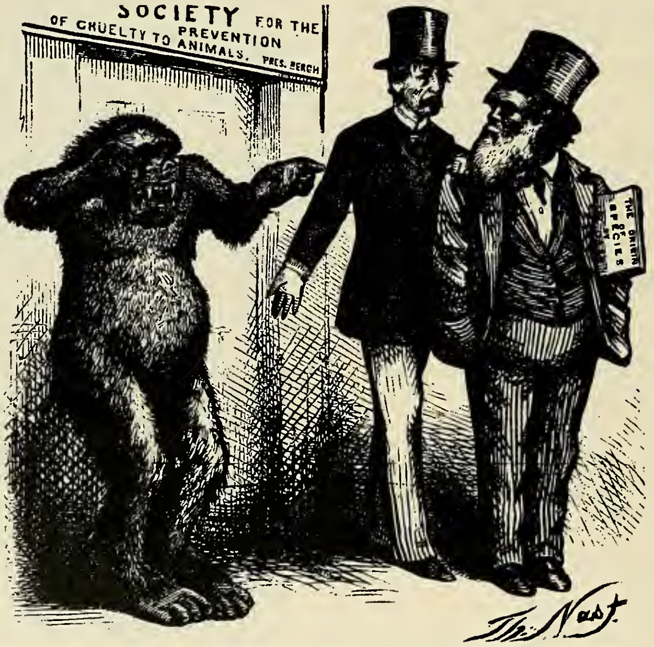
In scientific circles, the debate was on how evolution occurred. During the time covered by these articles (1913–1926), some scientists supported the theory of natural selection, others believed evolution occurred through large-scale mutations, and yet others saw evidence for natural laws that governed the overall direction in which evolution progressed. At the same time, experimental biology was a growing new field. Thomas Hunt Morgan, with his experiments with fruit flies, was revealing the complexity of the mechanisms of inheritance, and gaining the recognition that would win him the Nobel Prize. Paleontologists were continuing to collect and catalog fossils and interpret the record they uncovered.

The research, disagreement, and debate marked a prelude to the development in the 1930s and 1940s of a scientific consensus on evolution, which brought together, in a coherent theory, work in paleontology and genetics and a new statistical treatment of evolving populations. In this "modern synthesis" the two main ingredients were variation (random small-scale mutations) and natural selection.

These theoretical developments are not, of course, the whole story. The idea of evolution had its impact on the larger culture outside the laboratory and the museum. W.D. Matthew, for instance, managed to see a clear, progressive evolution in human morality. In 1920 he was convinced of the moral superiority of his contemporaneous moderns to even the heroes of the past. Matthew's ideas may seem quaint, but Henry Fairfield Osborn's notions of racial superiority are far from quaint. They are frightening, particularly because Osborn was not alone in his belief in the supremacy of whites, indeed of northern European whites. A number of other scientists shared such views, and they did not keep their ideas within ivory towers. Two years before Osborn's article, Congress passed, with considerable scientific support, the Johnson-Reed National Origins Act of 1924, setting up immigration quotas that favored northern Europeans.

To follow up all these articles, to bring evolutionary theory up to date, to trace the cultural impact of evolutionary ideas up until the present would require volumes. Today, the modern synthesis is itself being challenged, and the cultural ferment continues. Religious opposition to the idea of human evolution has never ceased, the innate endowments of human beings of different skin colors are still debated, and violent arguments continue over how much of human behavior and culture evolutionary theory can explain.

*James Gorman*


SOCIETY FOR THE PREVENTION OF CRUELTY TO ANIMALS.
PRES. BERGH
THE ORIGIN OF SPECIES
Th: Nast

*Gorilla: "That Man wants to claim my pedigree. He says he is one of my Descendants."*
*Mr. Bergh (founder of the A.S.P.C.A.): "Now, Mr. Darwin, how could you insult him so?"*

# A GREAT NATURALIST
# ALFRED RUSSEL WALLACE, 1823-1913

By HENRY FAIRFIELD OSBORN

THE nineteenth century in Great Britain, the Victorian Age, will be compared in history with the greatest intellectual periods in the history of Athens, of Rome and Florence. Brilliant as were England's achievements in art, literature and the spreading of civilization, her achievements in science outshine them all. No country has ever produced such a constellation of stars of the first magnitude in the same brief period of time, especially in the sciences of geology and biology. The dominant figure of course is that of Darwin, whose influence upon the world of thought is to be compared with that of Aristotle only. Anticipating and surrounding Darwin were members of an unrivaled group of men, beginning with Sir Charles Lyell, a geologist, and including Sir Joseph Hooker, the botanist, Alfred Russel Wallace, the naturalist, and Thomas Henry Huxley, the anatomist and natural philosopher.

Wallace, the last survivor of this remarkable group, died on November 7, 1913, in the ninety-first year of his age and the sixty-fourth year of service and discovery. He followed by only a few months another member of the group, Sir Joseph Hooker, who was present at the Darwin celebration at Cambridge in 1909, the centenary of the birth of Darwin.

Because the fame of Wallace rests chiefly on his codiscovery with Darwin of the theory of natural selection he is sometimes thought of as Darwin's contemporary but he was actually fourteen years younger and made the discovery of natural selection twenty years later than Darwin. He was always the first to recognize Darwin's seniority and leadership. In his remarkable journeys in South America and in the Malay Archipelago, filling the years 1848 to 1862, Wallace was influenced by Darwin's classic work, best known as the *Voyage of the Beagle.*

The simultaneous publication of the law of natural selection independently discovered by these two great naturalists was followed on the part of Wallace by a lifetime of devotion to this chief principle of Darwin's special theories of the causes of evolution. While Huxley was the stalwart defender of the evolution theory and of Darwinism in general without committing himself to either of Darwin's special interpretations of the theory, Wallace devoted himself continuously to the support of Darwin's special hypotheses. Yet almost from the first he differed from Darwin in some very important particulars. He never could bring himself to believe that the mind and spirit of man were the results of the same evolution process as that which had developed his bodily structure and that of all the lower orders of animal creation. As early as 1864 he advanced the hypothesis that so soon as man learned to use fire and make tools, to grow food, to domesticate animals, to use clothing, and to build habitations, the action of natural selection was diverted from his body to his mind and that thenceforth his bodily form remained comparatively stable while his mental faculties improved.

Five years later Wallace had definitely broken away from Darwin's conceptions with regard to natural selection and developed the opinion that this law is wholly inadequate to account for several of the bodily as well as physical characteristics of man, such as his soft and sensitive skin, his speech, his color-sense and his mathematical, musical and moral attributes. He drew the inference from this class of phenomena, that a superior intelligence has guided man's development in definite directions and for special purposes, just as man guides the development of many animal and vegetable forms.

Wallace like Darwin enjoyed the closing years of his life in the quiet surroundings of a beautiful English country home, and continued even to his ninety-first year to be a great force in the world's thought. His powers as a writer were prodigious and in rapid succession in his later years he brought out his volumes *My Life,* the *Wonderful Century,* the *World of Life,* and *Social Environment and Moral Progress.* In the *World of Life* he no longer believes in the Darwinian explanation of natural selection as adequate to account for the wonderful adaptations which we find in the animal world. He regards life as "a manifestation of creative power, directive mind and ultimate purpose." He thus returns in his later years to the teachings of his boyhood, to those which prevailed before the publication of the *Origin of Species.* His final creed is found in one of the closing paragraphs of the *World of Life:*

> In the present work I have endeavoured to suggest a reason which appeals to me as both a sufficient and an intelligible one: it is that this earth with its infinitude of life and beauty and mystery, and the universe in the midst of which we are placed, with its overwhelming immensities of suns and nebulae, of light and motion, are as they are, firstly, for the development of life culminating in man; secondly, as a vast schoolhouse for the higher education of the human race in preparation for the enduring spiritual life to which it is destined.

*APRIL 1915*

# MORGAN'S "HEREDITY AND SEX": A REVIEW

### BY E. G. CONKLIN

THIS book is the outgrowth of the Jesup Lectures for 1913 which were given by Professor [Thomas Hunt] Morgan at the American Museum of Natural History. It is a very difficult thing to make a book interesting to the general public and at the same time valuable to scientific readers, but this difficult task Dr. Morgan has accomplished in an admirable manner. His book is a work of extraordinary interest to the intelligent layman and at the same time one of great value to professional biologists, and its wide success is attested by the fact that the first edition was exhausted and a new one issued within a year.

With remarkable clearness and brevity the author presents the facts of the complicated structure of the germ-cells, their origin, maturation, union in fertilization, the way in which sex is determined and the mechanism of hereditary transmission. He accepts unreservedly the view that sex is determined at the time of fertilization; if the egg is fertilized by one type of spermatozoön a male is produced, if by the other type a female results. He also holds that the evidence is "almost convincing in favor of the view that the chromosomes are the essential bearers of the hereditary qualities." In favor of the chromosomal theory of heredity he presents evidences drawn from cytology, from experiment and from *sex-linked* inheritance. The latter is a type of inheritance, first clearly distinguished by Morgan, in which characters are transmitted to male or female offspring in exactly the way in which certain chromosomes are transmitted. On the other hand in *sex-linked* inheritance "the secondary sexual characters appear in one sex only and are not transferable to the other sex without an operation."

After discussing the principles of inheritance discovered by Mendel the author presents the results of his own work on the inheritance of sex-linked characters in the fruit fly. This is perhaps the most important part of this book, as it is one of the most valuable contributions to the study of heredity which has been made in recent years. The author concludes "that when inheritance factors lie in different chromosomes they freely assort and give the Mendelian expectation; but when they lie in the same chromosome they may be said to be linked and they give departures from the Mendelian ratios." Inasmuch as factors which usually lie in different chromosomes may sometimes come to lie in the same chromosome, Morgan has suggested that when the maternal and paternal chromosomes pair in the maturation stages

RALPH BARTON

*Among the statesmen present was always William B.*

of the egg or spermatozoön, the chromosomes of each pair may actually fuse at certain points where they cross each other and thus portions of the chromosomes with their factors exchange places. With this interesting hypothesis as a basis he has been able by means of his breeding experiments with fruit flies to plot the location of particular inheritance factors in individual chromosomes. This work, although in many respects hypothetical, is well supported by evidence and it is probably the most important work ever done on the "architecture of the germ-plasm."

This book was written on the firing lines, as it were, of biological science and it deals with many matters which are not finally settled. It is inevitable that such a book should encounter differences of opinion on the part of other investigators in this field, but the author is peculiarly happy in his manner of presentation. He writes as one who is convinced and yet tolerant and open-minded. His style is brief, keen, attractive, and best of all in a scientific work he shows a thorough, first-hand acquaintance with the phenomena described, and sound judgment and good imagination in dealing with them.

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*MARCH 1916*

# PROGRESS

A Drama of Evolution in Five Acts

BY T. D. A. COCKERELL

*Argument*—Evolutionary progress has not flowed in a single continuous stream from amoeba to man; it has branched and branched again, so that the ramifications are more numerous than the mind can follow. The most significant new branches have not arisen from the ends of the old ones, but as entirely new departures from the main trunk of the tree. Thus each great innovation, full of meaning for the future, has at first appeared to contradict the teachings of the past.

In these modern days, teachers, professing to hold the learning of the past, are telling us that we "cannot change human nature": that every wicked and vicious thing has its roots in nature, and however much it is to be deplored, it must be endured. This attitude is one of the deep fundamental causes of the present war. Let us learn indeed from the past, that significant progress is always possible, but through narrow paths, which to our eyes, blinded by the light of custom, seem dark and dangerous. Hazarding these byways, many of us must fail, but the few who succeed will win for the human race the rich prizes of the future. This is not mere sentiment; it is the teaching of science and of universal experience.

## Act I

*Beneath the waters of the ocean. Seaweeds, lobsters, crabs, mollusks, etc.*

*Time, Late Cambrian*

*Enter* AMPHIOXUS, LARVAL TUNICATE AND BALANOGLOSSUS

AMPHIOXUS. We are not much to look at, but we are
All in the way of progress.
Our backs are stiffened by a notochord, and all above
A slender nerve cord runs from fore to aft,
Prophetic of a brain. This tiny spot, this little speck of black,
Will some day be a pair of eyes, to knowingly survey the world,
While these gill slits, ranged on each side, already serve
To liven us with oxygen, gleaned from the waters flowing through them.
All in the way of progress to be vertebrates, and in days to come
Perchance, some creature with a soul.

LOBSTER. All in the way of progress! Are you mad?
I tell you, sirs, the progress of the past has not been thus.
In years so many that to count by millions is fatiguing,
In all the ages since the Cambrian dawn, and all the unknown times before
Was never such a thing.
Your nerve cord dorsal! Do you know
You're upside down? Clean topsy-turvy, and this somersault
You say is progress! You think the learning of the past
Is nothing. The spirit of creation, giving lobsters, crabs and snails,

Fine worms, starfishes and sea cucumbers: all this
Can now be set at naught, and you, clean upside down,
Will lead the van of progress!

[*All the animals laugh inordinately.*]

OYSTER. Our good crustaceous friend speaks truly; let me ask
Where would your progress take you?
What is a vertebrate, and what this thing
You say might have a soul?
No science teaches of such things, nor any story of the past;
A crab we know, a shrimp we know, a limpet is concrete and real,
But this absurdity you tell of, what is it?
A recollection of a dream that dreamed of dreams,
A twist of thought so meaningless that it is less than nothing.
Come friends, forsake your quest and be like us!

SEA URCHIN. Moreover, just consider how you look:
Small, soft and pallid or mud-colored.
No legs, no spines, no shell, no gaudy hues
To make you seem in fashion, and in form
To mix in good society.
In truth there's nothing in your favor save the claim
That you mean progress, and that notion's so absurd
It serves but to condemn you.

TUNICATE. Alas! What have we come to
In this mad quest for progress?
I fear 'tis as our friends declare, we're topsy-turvy,
And in seeking what is not, have lost what is.
For me no hope of excellence is left, no hope of being fit to stand
With lobster, snail or maritime cucumber. Yet I may show
My penitence in just one way, I may forego
These modern airs and change into a humble squirting sac.

BALANOGLOSSUS. And I also must hide my new conceits,
And simulate a worm. I pray you friends,
In charity pretend I am a worm.

AMPHIOXUS. Oh, comrades of such slender faith,
O'ercome by tory talk,
No future lies in store for you
But one dull round to walk.
Invertebrates you cannot be,
Nor vertebrates withal,
Alone among the beasts of sea,
The laughing stock of all.
My children are the heirs of time,
My sons will rule the earth,
When vertebrates come to their own,
And human things have birth.

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*OCTOBER 1916*

# THE LAWS OF SPECIES FORMING

BY DAVID STARR JORDAN

SOME years ago I ventured the statement that taking any given species of animal, the nearest related form would not be found along with it, nor at a great distance, but on the other side of some barrier which prevented intermingling.

This fact is almost self-evident, as far as the higher animals are concerned. We very rarely have any difficulty in determining the separate species in any given region. For this reason those naturalists who read the proposition have accepted it. Dr. J. A. Allen, one of the highest authorities on birds, went a little further and named it "Jordan's Law." But it existed in the nature of things before it was mine, and I can be credited with its ownership only for the sake of convenience in the discussion of the many ways in which life manages itself, which we call natural "laws."

In discussing the origin of species, we premise first that species in nature exist—but not as closed categories. They arise through the perpetuation by heredity of variants which are cut off from the original species by some sort of barrier of land or sea, of temperature or climate, of food or enemies. Once cut off, their inadaptive excrescences are pared away by selection, and at last the new species, as well as the old, comes to fit its environment as the river fits its bed.

As regards the vertebrate animals this is the origin of species. We can prove it in thousands of cases, as surely as we can prove anything by experiment when nature lays down its conditions. While now and then "mutations" or discontinuous variations occur, especially in domestic races of mixed origin, I do not know of a single species of vertebrate animal which could even hypothetically be supposed to have originated from a mutation.

Among the different races or variants of birds, none is recognized by name, or as having permanence, by competent ornithologists, unless these variants have a geographical basis. Subspecies are therefore geographical races, and these are the stuff that species are made of. The word geography should not be construed too literally; one does not need to go far up a mountain side, or into the depths of the sea, to find a condition of things radically different from those at sea level, on land, or in the ocean.

If there were one-thousandth part of the evidence for the origin of species by mutation that is shown for the origin by separation, the theory of de Vries would have standing in science. But to show that species arise in general through separation by barriers is not to exclude any other influence whatever. We know of no species however, which is not the product of internal influences —heredity with variation—modified by the external limitations arising from selection and isolation. Whatever else may be a factor in the formation of species in nature or in domestication, from these four we can never escape—heredity, variation, selection, and segregation.

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*JANUARY/FEBRUARY 1920*

# SIXTY YEARS OF DARWINISM

## A LOOK BACKWARD AND FORWARD

Molluscan shells of the sea-beaches and ocean beds of the millions of years of the past suggest that evolution works gradually and continuously along definite controlled lines—A field for future research

BY AMADEUS W. GRABAU

DARWINISM then, in the sense of the modern followers of Darwin, the Neo-Darwinians as they have been called, is the doctrine that the environment destroys the unfit and preserves the fit—natural selection takes place; that the essence of fitness is adaptation to the conditions of existence—the best adapted will survive and hand on to their offspring those characters which have made them fit; and finally, that these characters arise as the result of fortuitous variation; that is, variation apparently uncontrolled by any known law.

But the environment, too, is constantly changing; the Garden of Eden becomes a desert, roses bloom on the site of a prehistoric Sahara. "There rolls the deep, where grew the tree. . . . There where the long street roars hath been the stillness of the central sea." Adaptations, which under one environment insured survival, under changed conditions spell death. The *Megatherium*, the last of a long line of ground sloths, and well adapted to the food of its native haunts, became enfeebled as this food supply diminished in consequence of a change in climate, and so fell an easy prey to its chief adversary, the saber-toothed tiger. The sabertooth, in turn, fitted with tooth and claw adapted to hunting and stabbing to death those slow-moving thick-skinned herbivores, faced starvation when the last *Megatherium* was devoured, because from over-specialization this cat had lost plasticity to adapt itself to the swifter-footed grazing animals which formed the prey of its more agile cousins, the true tigers, the lions, jaguars, and the other great biting cats which still survive where man, their principal enemy, permits it.

The struggle for existence denies opportunity to the unfit; always and everywhere the fittest alone survive, always and forever the weak go to the wall. That is Darwinism pure and simple. Hope lies in a changing environment—the fit today become the unfit tomorrow. The law of the jungle cannot survive the jungle—the militarist cannot survive in a nonmilitaristic age—nor the Bolshevist the restoration of the reign of reason. When the environment of common sense is reestablished, the worker and the capitalist each again will find his place, and the advantage to all will be seen in the development of those qualities and powers which will make the unfit of today fit to fill their proper place in the united army of struggling humanity. That, too, is Darwinism.

But, I repeat, Darwinism is not the sole factor in evolution, at least not in the belief of many students of nature. To begin with, the value of fortuitous variations as a basis for selection is seriously questioned by many who cannot accept minute changes in form and character as of sufficient import to determine survival. Color harmony with the surrounding habitat may protect the animal by deceiving its enemy, the camouflaged ship has a chance to escape the lurking submarine, where the one not thus protected will be lost, but such adaptations are not small, they are large variations from the normal. A single stripe, the first step in the production of the protective design upon the vessel, will not serve the purpose of deceiving the enemy any more than a single green spot would serve a brown *Mantis* upon green grass, or the first step in the development of a pattern which makes the palatable butterfly resemble the distasteful one, deceive the hungry bird. But fortuitous variations are first steps, they are minute beginnings in the production of a serviceable whole and as such, cannot serve the purpose of the finished product. To have selective value the variation must be adequate; to become adequate it must either arise suddenly, or develop by cumulative additions in the proper directions without reference to immediate selectivity.

The attention of naturalists has of late years been directed to those larger and apparently sudden variations which are seen to arise occasionally in nature, and which are familiarly known as sports. The phenomenon is illustrated by the short-legged ram, which appeared suddenly in Massachusetts in 1791, and from which the race of ancon sheep, once prized because of their inability to jump fences, descended. Darwin at one time attached great value to such sports, but later on relegated them to a place of secondary rank.

But when the Dutch botanist Hugo de Vries discovered sports of the evening primrose (*Oenothera lamarckiana*) in a field not far from Amsterdam, and found by experiment that these forms bred true to type, that is, they were not fluctuating, but had constant new characters, the attention of the scientific world was again directed to this phenomenon, and careful breeding experiments became the order of the day. De Vries and most of his followers became convinced that not by minute fluctuating variations about a mean, but by sudden jumps, was progress made. From causes still unknown, the elementary characteristics of an animal or a plant now and then undergo a sudden rearrangement, much as the colored glass particles in a kaleidoscope are suddenly rearranged to form a new pattern, and this new organic pattern constitutes a new elementary species. Such an abrupt rearrangement of characters De Vries called mutation, others have called it saltation, and it is generally thought of as a process uncontrolled by any known law. To the De Vriesians the new elementary species thus produced are the only variations from the type which count. They alone are subject to natural selection; they alone mark the steps in the progress of the organic world.

*MARCH/APRIL 1922*

## RECENT DISCUSSIONS CONCERNING EVOLUTION

To the discussion regarding evolution, precipitated by the attack of the Hon. William Jennings Bryan upon the doctrine in question, several members of the scientific staff of the American Museum have contributed. In The New York Times of March 5 President Osborn made a thoughtful reply to Mr. Bryan, insisting that "truth is truth and must prevail" and expressing the opinion that if Mr. Bryan "with an open heart and mind, would drop all his books and all the disputations among the doctors and study first-hand the simple archives of Nature, all his doubts would disappear; he would not lose his religion; he would become an evolutionist." In The New York Evening Post of April 1, Dr. William K. Gregory, curator of comparative anatomy, showed the vulnerability of Prof. Francis P. Le Buffe's assertions, particularly as applied to the central exhibit of the hall of the Age of Man, in the American Museum. Dr. Gregory has also given a number of addresses recently on different phases of evolution. Before the Wagner Free Institute of Science in Philadelphia he delivered between March 4 and March 25 four lectures on "The Evolution of the Human Face," on March 29 before the Galton Society he presented "Notes on the Origin and Classification of Homo sapiens," and on April 10 before the New York Academy of Sciences a paper which he had prepared with the collaboration of Dr. Dudley J. Morton, entitled "Has the Human Foot Been Derived from a Gorilloid Type?" Dr. Robert Cushman Murphy, associate curator of the department of ornithology, spoke before the Park Church in Elmira—a Congregational church founded by a brother of Henry Ward Beecher—on "Bryan and Evolution," in which he pointed out that science has no quarrel with religion and then proceeded to present from many angles the evidence for evolution.

The Darwinian and the follower of De Vries have a common starting point—they both concern themselves with adult individuals. The voice of the elder Agassiz, crying in the biological wilderness of the early half of the last century, and exhorting naturalists to pay attention to the immature stages of animals and plants—those stages which lie between the embryo and the adult—has never reached their ears, or if they heard, they did not heed. But a disciple who followed the master in his wanderings through the underworld, where dead and forgotten generations of animal life had written their own epitaphs on tablets of stone, listened and learned and, by patient search among the ancient life records, became convinced that the new faith into which he had been baptized, pointed the true way to biological salvation. Alpheus Hyatt proved what Agassiz preached, that the immature stages of an animal's life history furnish the key to its racial history, that the young animal repeats the adult characters of its ancestor which lived in the immediately preceding geological period, and that this ancestor in turn had repeated in its own youthful stages the characteristics of a still earlier member of the tribe. Agassiz did not accept the doctrine of evolution, but Hyatt recognized the philosophic bearing of the facts uncovered by his researches. Step by step, the history of each individual type carried him backward in the history of the race until the beginning was reached. Down the long corridor of time he passed and took his pupils with him. Eagerly each new inscription was scanned, and each pupil selected that which to him seemed most promising, and then began to unwind the long record of ancestral achievement. And whenever the way seemed long, and their courage began to fail, new vistas would open, and the pursuit regain new vigor. And in this quest it became increasingly more apparent that variation was not fortuitous nor indefinite, but controlled along definite directions. To be sure, the controlling force has not been revealed, but the very definiteness of the variation leaves no doubt as to the existence of such a control.

*SEPTEMBER/OCTOBER 1920*

# THREE-TOED HORSES

## A Fossil Record that Provides Direct Evidence of Evolution

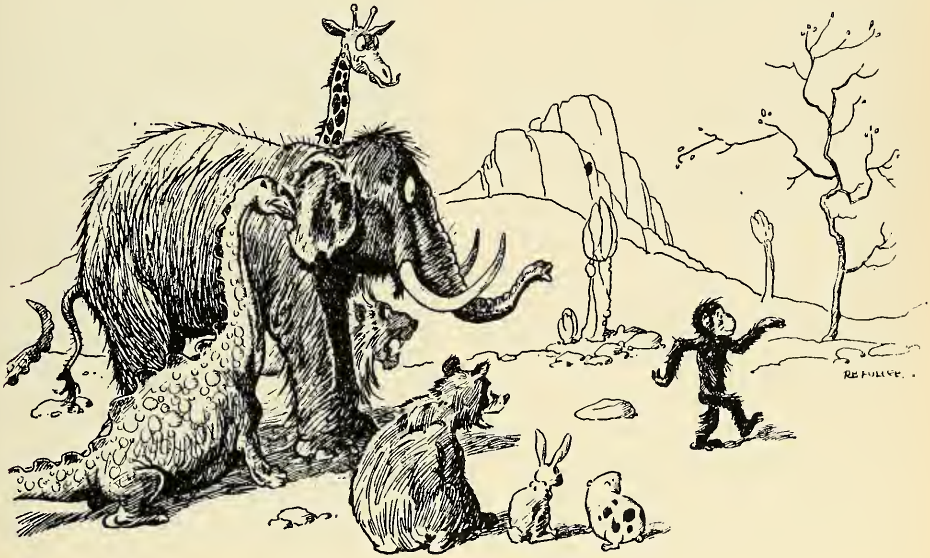
By W.D. MATTHEW

WHAT were these three-toed horses anyway? Why are they so important or so interesting that literally thousands of scientific papers have been written about them. Briefly, they are thus important because they can afford one of the best records by which to test the truth of the theory of evolution.

The theory of evolution—commonly but wrongly called "Darwinism"—is an attempt to explain the present diversity of living beings and their various resemblances and differences in structure as due to their descent from common ancestors and the slow, gradual changes in each race in adaptation to its particular mode of life. The doctrine of natural selection—Darwinism properly so called—gives as the cause of these changes the gradual accumulation through innumerable successive generations, of such minute differences as we find always exist between individuals and tend to be inherited by their offspring.

All the evidence for evolution found in the anatomy and structures and habits of animals, in their relationship and distribution, in the growth and development of the individual, in the breeding and selection of domestic animals and of plants, and in the so-called "experimental evolution" which has converted into a science the practical knowledge of the breeder, is, after all, indirect evidence. However uniform its inferences, however overwhelming its weight, however perfectly and admirably it explains innumerable details of structure and habit for which no other reasonable explanation can be found, it would be as nothing if palaeontology were against it. If the actual remains of fossil animals showed that they had always been as they are now since they first appeared on the earth, then, indeed, we would have to sweep aside the beautiful theory of evolution with all the exquisite perfection of its explanations of every tiny detail in the complex structure of the higher animals, as an iridescent dream. We would have to say to the anatomist, to the embryologist, to the experimental evolutionist: "Oh, yes! Your interpretations and analogies and experiments are ingenious and interesting, but you can't prove evolution by them for they are in conflict with the plain facts. The record of what actually has happened shows that species *did not* come into being that way. They were created in the beginning just as they are."

But the fossil record, this plain, direct, and unalterable record of what *did* happen during the past history



*The upstart*

of the earth, *does* prove evolution, and wherever it is complete enough, it proves it so directly and conclusively that it removes it from the category of theories to that of facts. It is, indeed, a very incomplete and fragmentary record. It owes its preservation and existence rather to the chapter of accidents than to the normal cause of circumstances. But, whenever there is anything approaching a consecutive detailed record of any race or type of animal, it becomes perfectly evident that the race or type has not come into existence in its present form, but has changed through numerous small or minute gradations from an original type which is hardly or not at all distinguishable from the original form that gave rise to other races or types now widely different.

The best evidence of this sort is to be found among the invertebrates, especially among mollusks, which include many cases where the gradual change in a race can be followed by numerous specimens from each stratum.

But while the evidence of these invertebrates affords conclusive proof of evolution to the palaeontologist, it is not always convincing to the layman. Many people may be willing to admit that one species of clamshell has changed gradually into another, but they will deny vigorously that a horse and a tapir are descendants of a common ancestral stock, and angrily resent the imputation that they themselves are blood relatives of the chimpanzee and the gorilla. Such a position is illogical, if they only knew it, for if the proofs of evolution in the anatomy of the lower animals are shown to be in accord with the facts of their past history, then the much stronger evidence in the anatomy of the higher animals must mean the same thing in their case. But it is natural enough, for the objections to evolution center around the descent of man, and the average anti-evolutionist will hardly see that his traditional view is endangered by anything so remote as the humble mollusk.

The evolution of the horse, however, comes near enough home to shake his confidence if he is opposed, or to assure his belief if he is in favor of the theory of evolution. It is not the record in which we are most interested, namely, that of the evolution of our own race. But it is that of one of the most familiar domestic animals, the changes in the structure of the skeleton are obvious and the reasons for them easily understood, and the record of the evolution of the race is a fairly complete one so far as it goes.

The present distribution of the horse family, aside from domestic horses, is limited to Africa and central Asia. In the latest geological formations, however, of the Pleistocene epoch, we find fossil remains of various species of horse in all parts of Europe, Asia, and Africa, North and South America. These species are all closely related to the existing horses, one-toed, and with teeth entirely similar to the modern species.

In the next preceding epoch, the Pliocene, we find fossil horses both in the Old World and the New, and some of them in the later part of the Pliocene of Europe are also closely related to the modern horse and are placed in the same genus, *Equus*. In the Lower Pliocene we find three or more genera all evidently related to the horse but of smaller size, with the side toes less reduced, completely formed in some species. In the Miocene there are numerous species, all of them with the side toes complete but small and slender, seldom reaching the ground. They average about the size of a donkey, and their teeth are shorter crowned than in the later horses. In the Oligocene the horses are still smaller, averaging about the size of a sheep, the side toes are less reduced so that they reach the ground and help support the animal, and the teeth are comparatively short crowned with simpler pattern. In the Eocene the horses are still smaller, averaging about the size of a terrier dog, their side toes are quite large, and in the forefoot there is a fourth digit, so that these are known as "four-toed horses." The teeth are still shorter crowned and simpler in pattern.

These are merely the outstanding stages in a long succession of intermediate gradations that connect the modern horse with the little four-toed *Eohippus* of the Lower Eocene. Each gradation is found in its appropriate geological stage, and not earlier or later. The changes and gradations are seen just as clearly in every bone of the skeleton as in the feet and teeth, and the gradual evolution of the race is thus shown by direct and overwhelming evidence. You may indeed, if you choose, declare that each successive gradation was independently created. Direct proof on that point is not at hand; the genetic continuity rests upon inferential evidence. But that the race as such evolved gradually, little by little, through the millions of years of the Tertiary period, is a matter of plain fact and record.

It is equally a matter of record that the now diverse types of tapirs and rhinoceroses evolved gradually from a common ancestral stock with the horses; and that all the records of other races of mammals show them converging backward in time toward a common stock. The *Eohippus* is by no means as different from man as is the modern horse and he is far closer in every detail of his construction to the Eocene representatives of the group to which man belongs (the Primates) than he is to man. All other races of animals display the same convergence toward a common ancestry in every detail of the teeth and feet and skeleton.

The evolution thus shown as a fact of record in certain portions of the history of various races which have been preserved to us in the history of life, appears to be a sure inference as applied to the whole, supported as it is by the community of fundamental structure that prevails through the whole living world, by the obvious adaptation of each race to some particular habit of life, by the proof that natural selection can and must operate to bring about changes in the structure of the race in adaptation to its habits. If we recognize that the records, where they are preserved, show evolution to be a fact, we cannot logically refuse to admit it in the undiscovered portions of the record, upon the force of the immense amount of inferential evidence in its favor, and, in conclusion, because it is the only real explanation of life, the only one that rests upon natural law.

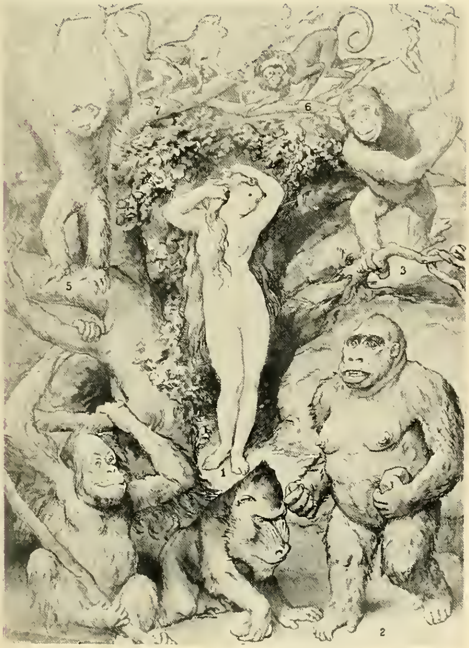
*SEPTEMBER/OCTOBER 1920*

# SOCIAL EVOLUTION: A PALAEONTOLOGIST'S VIEWPOINT

### BY W. D. MATTHEW

IN a recent address a well-known newspaper editor is quoted as saying: "To me the lack of proof of any improvement of the human mind as far back as history goes is the most impressive proof of the creation of the human mind, against the theory of evolution."

There is, however, another aspect of the human mind in which I think there is very clear evidence of progress. This is the moral or ethical as contrasted with the intellecual side. Here, I think, one may see both in precept and in practice, a marked advance, a steady improvement, fairly continuous upon the whole, and resulting in a notable contrast between the standards that we see represented in the writings and actions of early peoples, and those which prevail today. I use the term "moral qualities" in its broadest sense to include all those inhibitions and restraints, those actions and thoughts which prefer the ultimate advantage of the individual to his present advantage, which sacrifice a lesser individual benefit for the greater race benefit, which tend to the development of social life and more elaborate social organization.



*"Apotheosis of Evolution," by E. Haeckel and G. Max*

Consider the moral standards of the Old Testament as compared with those of today. How would we regard David, "the man after God's own heart"? An able warrior, no doubt, clever, active, well-meaning, magnetic, a good fellow on the whole, but surely something of a weak brother. How would he measure up with Washington, with Lincoln, with William Pitt? "The righteous man sweareth an oath and keepeth it even though it be to his own hindrance." Surely that is not so remarkable in the modern righteous man as to call for special and rather surprised commendation. "An eye for an eye and a tooth for a tooth." Are these the ideals of our modern treatment of criminals? Rather, one would say they are the standards that prevail among the criminal classes themselves.

Or, take the matter of self-control, of the regulation and management of one's daily life and habits. How many of the kings and leaders of olden time were able to withstand prosperity, to refrain from indulgences that shortened their own lives and ruined the prestige of their dynasties in one or two generations? Does not the whole of ancient history leave one with an impression of gorging and feasting without regard for the morrow, of snatching at the pleasures of the moment often at a terrible future cost? Contrast with this the sober regularity of the average civilized man of today, the diligence and abstemiousness of most modern leaders, political or financial. It is useless here to cite examples, but I cannot but be impressed by a marked difference in averages.

Now all this is exactly what we should expect on the Darwinian theory. Five thousand years, the most that we can give to such historical records as bear upon the present problem, is too short a time, if measured by the recorded rate of progress in evolution, to produce any perceptible change in the physical structure of man. And his intellect, based as it is upon the physical structure and complexity of his brain, should show a similarly slow rate of change. The specialist distinguishes with difficulty between the skull of an extinct horse of the early Pleistocene and that of its modern descendant. Whether we estimate the length of the Pleistocene at 100,000 years or, as high modern authorities insist, at a million or more, it is obvious that the evolutionary change in this race during five thousand years would be imperceptible. And this is equally true of any other race of mammals of which we have a good evolutionary record. By this measure one would not expect to see any appreciable evolutionary change in the brain and intellect of man since history began. On the contrary, if a marked and obvious improvement in brain or other physical characters had taken place during that time, it would constitute an exceptional case of abnormally rapid evolution, calling for explanation.

On the other hand, the moral qualities may be viewed as partaking rather of the nature of fixed habits, viewpoints, instincts, not directly correlated with the complexity of the physical brain structure, and like other instincts and habits, much more variable and more rapidly modifiable than the physical structures of the body and functions directly dependent upon them.

Natural selection will seize upon those variations which are most useful for the individual or for the race, and will accumulate them in proportion to the rate at which they can be modified. Obviously the moral qualities of man have for many centuries been at least as important for his social advantage as any intellectual or physical superiorities for his individual advantage. Because of their being more rapidly improvable, the principal advance has been in these qualities. Indeed, I find it difficult, as a palaeontologist, to look upon human history as other than a splendid record and display of the operation of natural selection applied to races instead of individuals, and resulting in social, not in individual, evolution. This process of social evolution with its rapid changes leading often to an astonishingly elaborate and perfected organization, is by no means confined to man. It is illustrated again and again, in various stages of its development, throughout the animal kingdom. The traces of its existence in extinct races are naturally obscure and difficult to decipher; we are dependent upon observation of living animal societies and inferences as to the evolution of their habits.

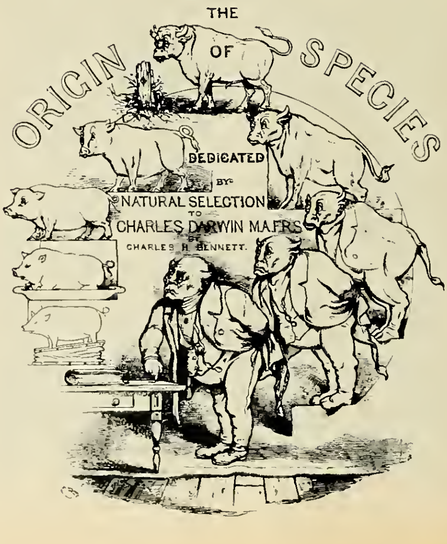
From observation and comparison of such modern social communities, one may perhaps draw certain conclusions as to the trend and limits of social evolution, and apply them to the future of our own race.

(1) Marked tendency to a progressive uniformity and fixity of type and habits. In the early stages of social development one may observe a considerable flexibility and individual initiative, a greater variation in the action of the individual under given conditions. In the more elaborated types of social life the individuals of each class appear to think, act, and feel alike and to perform their respective duties in a more uniform and automatic way.

(2) Although amazingly precise and elaborate social relations are found among lower animals—insects especially—yet the complexity of the community life appears to be limited in many ways by the intelligence of the individual. None of the higher animals has carried social life to the extremes of precision and exact coördination that we observe among the social insects; in none of them is the individual so far sacrificed for the benefit of the race. Yet the complexity of the social life of the higher animals is in some respects greater—in man it is far more complex.

The ultimate result of social evolution would seem to be a precisely adjusted, uniformly acting organization, working with the automatic accuracy of the complex association of cells of which each individual is composed. The degree of complexity which such an organization can attain before it reaches that precise adjustment depends, as I see it, upon the intelligence of the individual units which compose it.

If this be true, we must conclude that once such a finished social mechanism has been perfected, its further progress must be relatively slow. While up to this stage its evolution has depended upon the modifying and perfecting of the moral or social instincts, henceforth it must depend upon the far slower evolution of a higher physical and intellectual type. From the short perspective of human history this phase of physical and intellectual evolution is so slow as to be negligible. We may fairly say that our present trend of social evolution will tend to advance to a civilization far more complex, far more precise in its adjustment, to continually more uniform group-types of individuals, not appreciably higher in intellect but very much higher in morality; to eliminate more and more completely the criminal, the idle, the selfish individual, the unsocial of every type; and to reach finally the goal of altruistic endeavor. This cannot be reached, however, in a generation; such a mechanism involves much higher standards of morality than now exist in the average man, and requires also the elimination of all who fail to measure up to them. But that this process is going on, and has been going on for some thousands of years, I, who read history in the light of palaeontology and evolution, cannot doubt. Nor have I any doubt as to its ultimate outcome, regrettable in some respects, desirable in many others, to the individual who, with growing social instincts, still retains some of the flexibility and impatience of restraint and uniformity that are inherited from his remote forebears of the wild tribes of primitive man. But what will be, will be. We may try to read the future if we will; we cannot alter it.



*JANUARY/FEBRUARY 1926*

# THE EVOLUTION OF HUMAN RACES

BY HENRY FAIRFIELD OSBORN

FRANCE, from the close of the eighteenth century, was the leader in Anthropology, the science of man. In 1875, Armand de Quatrefages, professor in the Museum of Natural History, Paris, delivered a course of elementary lectures on "The Natural History of Man" to audiences of working people in Vincennes. These delightful lectures represent the pre-Darwinian point of view and dwell with emphasis upon the *unity* of human species and upon the intellectual, moral, and spiritual distinctness of man.

In support of his opinion that all the greater and lesser divisions of the human race belong to a single species, namely, *Homo sapiens,* Quatrefages observes: *"Fertility is the law of union between animals belonging to different races* (mixed breeding)," whereas *"infertility is the law when animals of different species unite* (hybridization)." This argument is now known to be invalid; we know that, both in nature and in experiment, many distinct species and even distinct genera of plants and animals occupying over-lapping geographic areas interbreed freely and may leave a long series of hybrid descendants, some of which are highly useful both in plant culture and in animal culture.

If an unbiased zoölogist were to descend upon the earth from Mars and study the races of man with the same impartiality as the races of fishes, birds, and mammals, he would undoubtedly divide the existing races of man into several genera and into a very large number of species and subspecies.

There has been a profound change both in our knowledge of facts and in our theories and conceptions since the time of Linnaeus and even of Quatrefages, through anatomical researches among the Asiatics and Africans. This is the recognition that the genus *Homo* is subdivided into three absolutely distinct stocks, which in zoölogy would be given the rank of species, if not of genera, stocks popularly known as the Caucasian, the Mongolian, and the Negroid:

*Homo sapiens europaeus*—North and south Eurasiatic stock, wavy hair (cymotrichous) with intermediate cross section. Broad- or long-headed. Tall to medium stature. (= CAUCASIAN.)

*Homo sapiens asiaticus*—Extreme East Asiatic stock. Straight hair (lissotrichous) with round cross section. Broad-headed. Medium to tall stature. (= MONGOLIAN.)

*Homo sapiens afer*—African stock. Closely curled hair (ulotrichous), flattened cross section. Narrow-headed. Short to tall stature. (= NEGROID.)

The spiritual, intellectual, moral, and physical characters which separate these three great human stocks are far more profound and ancient than those which divide the Nordic, Alpine, and Mediterranean races. In my opinion these three primary stocks diverged from each other before the beginning of the Pleistocene or Ice Age. The Negroid stock is even more ancient than the Caucasian and Mongolian, as may be proved by an examination not only of the brain, of the hair, of the bodily characters, such as the teeth, the genitalia, the sense organs, but of the instincts, the intelligence. The standard of intelligence of the average adult Negro is similar to that of the eleven-year-old youth of the species *Homo sapiens.* The wisdom teeth of the Negro are erupted at the age of thirteen; the wisdom teeth of *Homo sapiens* are erupted between the ages of twenty-one and thirty, if at all. The young Negress may produce her offspring at the age of eleven; the early maturing Hindoo woman of Caucasian stock may produce offspring at the age of twelve. Hundreds of other differences might be cited. This is not said in disparagement of the Negroid race, which displays many noble qualities of spiritual and moral character, as observed by sympathetic and unprejudiced travelers like Herbert Ward, whose sculpture has also revealed the superb physical development of the native Negro.

The Mongolian is somewhat less profoundly different from the Caucasian than is the Negro. The intelligence and morale of the Mongolian may fully reach the high Caucasian level, as shown in great periods of Chinese history, but his physical development seldom equals that of either the Negroid or the Caucasian, which give rise to the tallest races in the world.

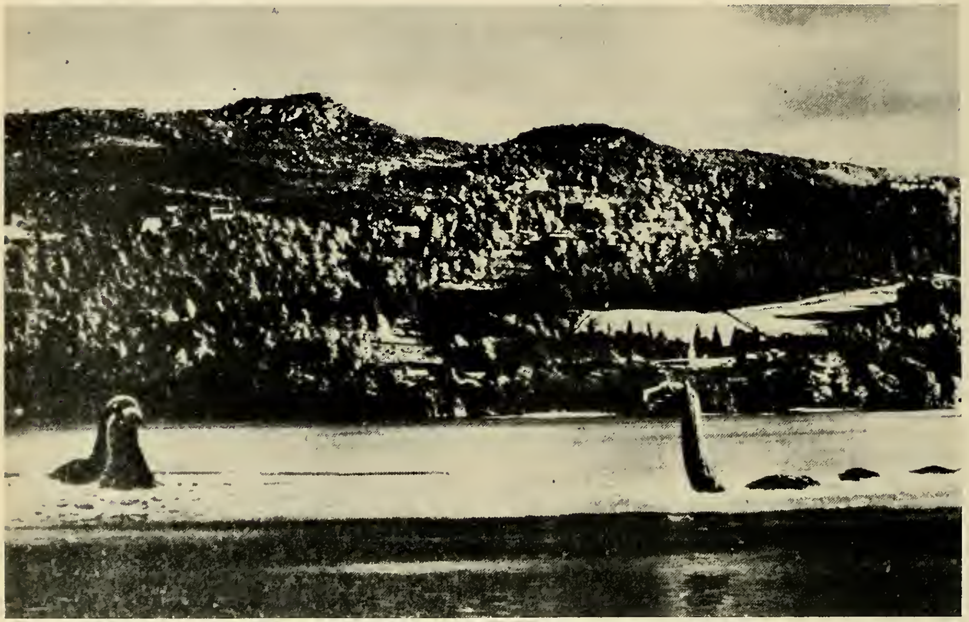
The hair happens to be one of the most conspicuously distinctive and constant features of these three species of man. Skin color is less uniformly distinctive. The Mongolians are yellow to dark brown or bronzed in skin color. The Negroids are generally dark brown to full black. The Caucasians are extremely fair-skinned in the North, light-brown-skinned in the South, very dark-brown-skinned in subtropical Polynesian hybrid branches, like the Hawaiians.

Each of these human species interbreeds with the other and produces a great variety of half and quarter breeds. Thus *inter-fertility is not a bar to specific distinction or even to generic distinction in mammals.* In the family of Bovidae, for a parallel, several genera and species freely interbreed, e.g., our domestic cattle (*Bos taurus*) and the bison (*Bison americanus*).

*NOVEMBER 1934*

# THE LOCH NESS "MONSTER"

BY WILLIAM K. GREGORY



*Two "monsters" in a single loch. A sinful waste of native talent!*

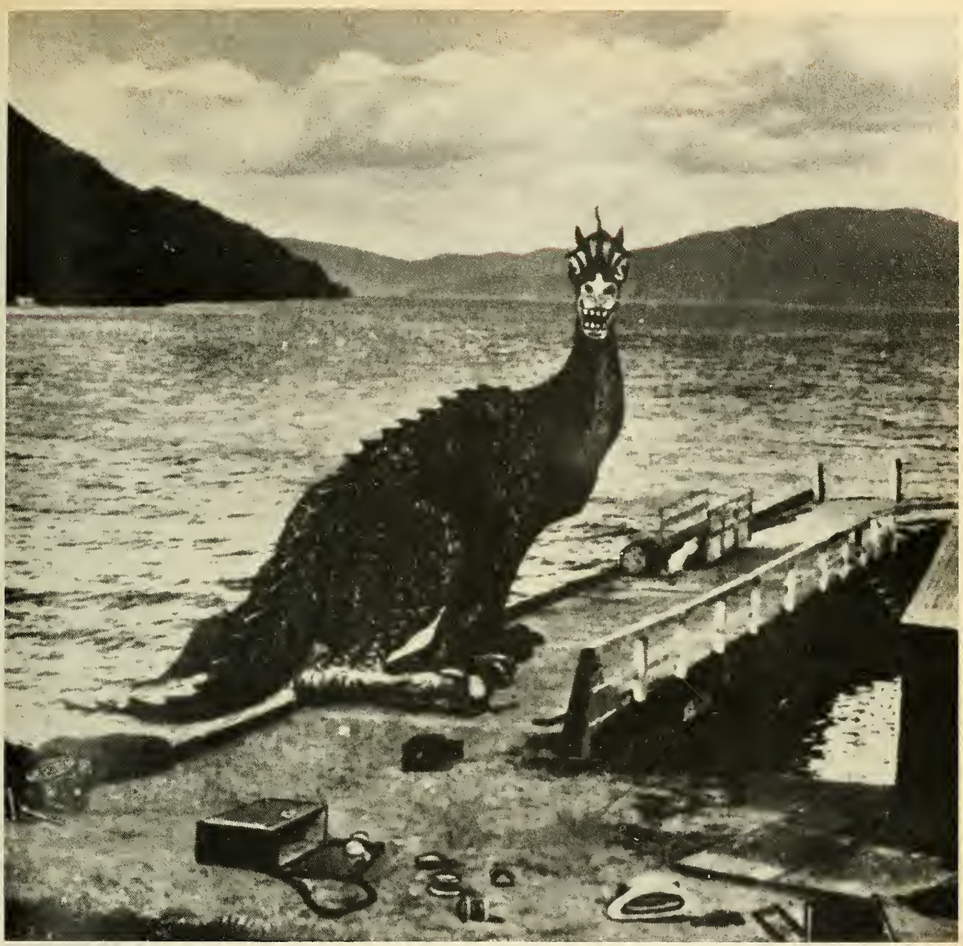
ON a recent trip to the north of Scotland I stopped off for a while at Inverness, which is the home port of the "Loch Ness monster." Inverness is as romantic and beautiful as only a Scotch city can be, with its castle and kirk and verdant hills. A swift-flowing stream carries the clear waters of the long, narrow Loch Ness northeastward to the Moray Firth. So I stood thoughtfully on the suspension bridge underneath which the Loch Ness monster must have passed if it came in from the North Sea. At that time the water was pretty low, but in time of flood a good-sized seal or even a killer whale might easily have passed up into the Loch in pursuit of salmon.

The latest "photographs" of the "monster" look like the dorsal fin of a killer whale.

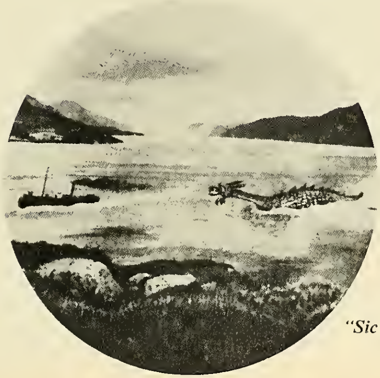
One hesitates to contradict twenty million Scotchmen, especially on their home grounds, but I noted for future use that *"Nessum monstrosum,"* as the animal has been facetiously named, must be a creature of protean form and varying proportions. In a guidebook to Loch Ness it is described and figured as an overgrown edition of the Japanese "giant salamander," which is a four-foot mud puppy with a head that has been flattened as if under the foot of a behemoth. Another veracious artist, however, represents the head as long and narrow, but with a giraffe-like tongue. Unfortunately, the lower jaw is not articulated at the posterior end. A third depicts the monster as emerging from the Loch and looking like a feeble libel on Charles R. Knight's well known restoration of *Allosaurus.* A fourth imaginative genius has produced a masterpiece by combining the features of several reptiles and mammals with the back fins of a teleost fish. But nothing but the *corpus delicti* satisfies the relentless scientist.

The fair city of Inverness teems with souvenirs of its beloved monster: postcards *ad lib.* in the Scotch equivalent of the "Five and Ten," little bronze monsters in the jewellers' shops, wooden monsters for the bairns to ride upon, and rubber monsters to take in bathing in the already chill waters of the Loch. And the silver tide of tourists still runs high. Surely the good beast is the greatest benefactor of his country since Sir Walter Scott. But why pick on Scotland for this innocent and profitable amusement? Many a country could show worse pastimes in the present period of world history.

*The Loch Ness monster has never been found and no one yet knows whether it is real or a hoax.*



*This obliging beast shows off his mammalian face and hind feet combined with reptilian scales and tail*



*"Sic 'em, Rover"*

# Celestial Events

by Thomas D. Nicholson

**Sun and Moon** The April sun moves out of the constellation Pisces into Aries on the 19th, and into Taurus in mid-May. Note that the sun was in Pisces when it passed the vernal equinox, even though that point along the sun's path also bears the name "First Point of Aries," reflecting the position of the vernal equinox 4,000 years ago.

The moon is just past full on April 1 (no fooling!), reaches last-quarter on the 8th, new on the 14th, first-quarter on the 21st, and full again on the 30th. Last-quarter occurs again on May 7, new moon on the 14th. Perigee moon (nearest the earth) is on April 14 and May 12, apogee (farthest from the earth) on April 26 and May 24. The perigee of April 14 will enhance the spring tide produced by the new moon some twenty-one hours later.

**Stars and Planets** If you haven't met Venus yet, do so at once while it still has some of its best nights ahead. Look into the west any clear evening after sundown, and the brilliant planet will be high in the sky, nearing its brightest in early May. It passes the Pleiades and Hyades (in Taurus) in early April, and the moon moves south of it on April 17 and 18 and May 16.

The sky around Leo, where Jupiter, Mars, and Saturn frolic near Regulus, is also worth getting to know early this month. After dark, Leo and the planets are in the east, opposite Venus, but they remain visible all night, disappearing in the west near dawn. The three planets reverse directions in April and May. Mars passes close to and above Regulus and Jupiter within less than a week in those months and Saturn in mid-June. Mars remains exceptionally close to Jupiter and Regulus throughout the two months, although dimming as it moves away from the earth, and the three are highlighted by the moon on April 23 and May 21. The moon covers Jupiter and Saturn (also the planet Mercury and the bright stars Regulus and Aldebaran) repeatedly in April and May, but the occultations will not be readily visible from the United States.

April 2: Mercury, at greatest westerly elongation, is a poor morning star.

April 5: Venus, at its greatest distance to the left (east) of the sun, is an excellent evening star. It will be spectacular for the next six weeks.

April 7: Mars ends its retrograde (westerly) movement, turns back east toward Regulus and Jupiter.

April 17–18: The moon is close to Aldebaran and Venus these nights.

April 21–22: The Lyrid meteors (15 per hour) reach maximum.

April 23–24: The moon passes Mars, Regulus, and Jupiter within four hours, after midnight.

April 25–26: The moon is very near Saturn tonight. Jupiter, ending its retrograde movement, turns around to move away from Regulus and toward Saturn.

April 27: Communities using daylight time shift clocks ahead.

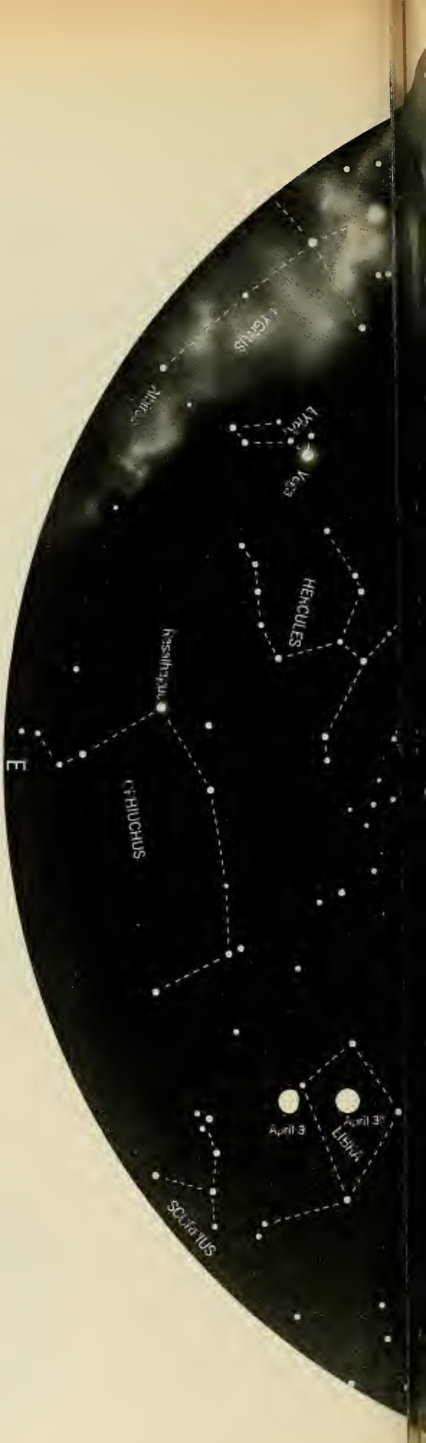
April 29–May 4: Mars moves past Regulus on the 29th, Jupiter on the 4th. The Eta Aquarid shower (20 meteors per hour, but swift and often bright) reaches maximum on the 4th.

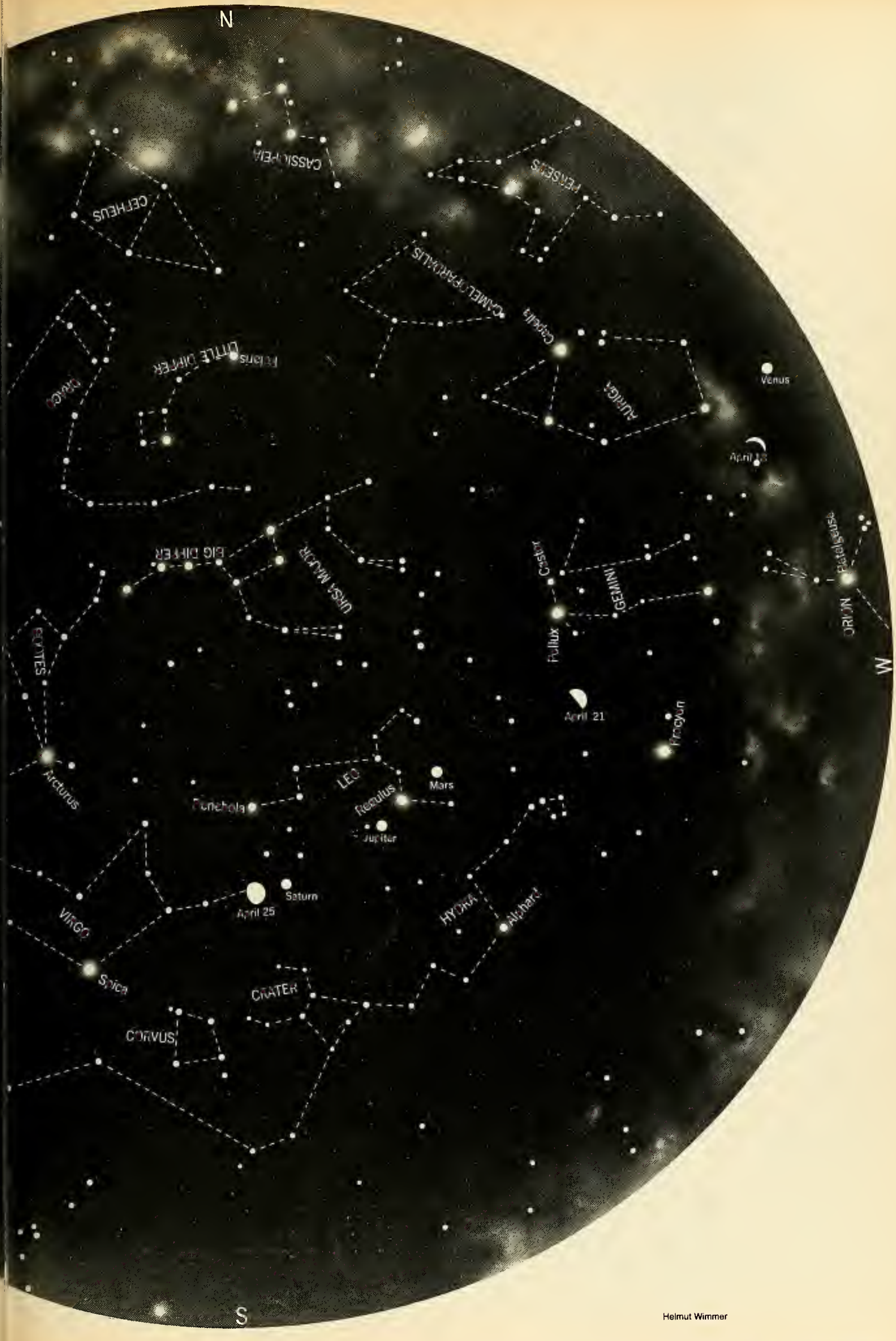
May 8: Venus is at greatest brilliancy in the evening sky.

May 13: Mercury, in superior conjunction, becomes an evening star.

May 15–16: The moon again passes close to Aldebaran and Venus (more distant). A daytime occultation of Aldebaran occurs over North America about 9:00 A.M., EST, on the 15th.

★Hold the Star Map so the compass direction you face is at the bottom; then match the stars in the lower half of the map with those in the sky near the horizon. The map is for 11:15 P.M. on April 1; 10:20 P.M. on April 15; 9:20 P.M. on April 30; and 8:25 P.M. on May 15; but it can also be used for an hour before and after those times.




N
CASSIOPEIA
CEPHEUS
PERSEUS
CAMELOPARDALIS
Capella
LITTLE DIPPER
Polaris
DRACO
AURIGA
Venus
April 18
BIG DIPPER
URSA MAJOR
Castor
GEMINI
Betelgeuse
ORION
Pollux
W
BOOTES
April 21
Procyon
LEO
Mars
Arcturus
Denebola
Regulus
Jupiter
Saturn
April 25
HYDRA
Alphard
VIRGO
Spica
CRATER
CORVUS
S

Helmut Wimmer

by J. Derral Mulholland

# The Chandler Wobble

*Small aberrations in the motion of the earth's axis may be associated with other terrestrial phenomena*

When Galileo Galilei, speaking of the earth, is supposed to have said "and still it moves," he could not have imagined how complicated are the ways in which the planet does in fact move. He was convinced by the Copernican theory that we are in orbit around the sun. Maybe he realized that the slow motion of the equinox through the constellations is caused by a motion of the earth's axis relative to the stars. But our planet, tugged at by forces from its neighbors and flawed by its own imperfections, also moves in less obvious ways. It wobbles on its axis and pulsates with the tides; it slows down, then speeds up, only to slow down again. The study of these small internal motions of the planet is now called geodynamics, and it forms a major element in our national scientific research program.

Geodynamics was born in 1891 with the discovery that the earth's crust slips around with respect to the rotation axis. The North and South Poles move around the axis, so this is called the polar motion. The area covered by this wandering is only about thirty feet in diameter, barely the size of a motel swimming pool, but it may be related to large-scale earthquake activity, tectonic motions, variations in atmospheric circulation, and possibly to climatic changes. The first step toward understanding those speculative correlations, which, in turn, may provide a possible basis for predictive theories, is to find out by observation what the earth is actually doing. Until now, the earth has frustrated the theorists.

The linkages will seem less mysterious if we first know the background of the discovery of the polar motion. The story is of sociological as well as geodynamic interest because it pitted an untrained amateur scientist against contemporary scientific leaders, and the amateur won. He won because he didn't know enough to make the wrong assumptions.

Perhaps the first person to realize that a polar motion should exist was Leonhard Euler, the eighteenth-century Swiss mathematician who developed the theory of rotating bodies. Scientists already knew that the earth is not a sphere, but is slightly squashed at the poles. The distance from North to South Pole through the earth's center is about fifteen miles shorter than the diameter of the equator. Because of this, the earth spins like a child's off-center top. The top spins but if it is not vertical, the spin axis wobbles. This wobble is called a precession if it is very slow or a nutation if it is faster. The earth's spin axis precesses with a period of twenty-six thousand years, which we see as the motion of the equinox through the constellations of the zodiac. Euler predicted that, in addition, the axis should rotate with respect to the solid earth, by a very small and unpredictable amplitude, with a period of ten months.

We like to think of the earth as solid, as terra firma. The sheer solidity of the ground under our feet has been a comfort to untold generations of humans who have ventured onto the sea or into the sky. But solidity is an ambiguous idea. In high-school chemistry, we learn that a "solid" is something that "keeps its shape." Since our intuition of "shape" is largely formed by the abstract idealizations of Greek geometry, our understanding of solidity is often confused with the idea of "rigidity." In our intuitions, the lumpy spheroid that is our earth is transmuted into a sphere. To say that a sphere keeps its shape means that it is always a sphere—rigid, unchanging through the ages.

We know, of course, that this does not describe the real earth. On the most trivial of levels, the ocean tides ebb and flow twice a day. More seriously, a few years back, those living near San Fernando, California, saw the San Gabriel Mountains rise four feet within a few minutes. The view from California's Owens Valley provides spectacular evidence of crustal motions, with more than 3,000 feet of uplift in a single epoch. The earth is not rigid.

Still, one has difficulty imagining that its nonrigidity is very important. Aren't the tides just surface phenomena, involving only a little bit of water? Surely, even massive earthquakes move only small pieces of the earth. The force of intuition is so strong that scientists, too, are prone to think this way. For them, there is an even stronger incentive—the mathematics is much simpler for a rigid body.

Euler predicted that the axis of the "rigid earth" should move in a small circle around the geographic pole, with a period of ten months. This would cause the apparent latitude of all places on earth to change, also with a ten-month period. In principle, this circular movement would be found by measuring the positions of stars in the sky. The amplitude of the motion was too small to be found with the astronomical techniques of Euler's time, but in the nineteenth century Lord Kelvin, the British mathematician and physicist, revived the idea. Noting that telescopes were much improved, he urged observers and theorists to look for the latitude variations. A specific request in the late 1870s to the dean of American astronomy, Simon Newcomb, produced no more success than previous astronomers had had. The problem was that although everyone knew exactly what was being looked for—the amplitude of Euler's predicted ten-month variation in the earth's axis—no progress was possible because the prediction was wrong.

The first breakthrough came from a study totally unrelated to polar motion. A study of stellar aberration, that is, the apparent changes in star positions due to the finite speed of light, concluded that the observations were contaminated by a latitude variation in the

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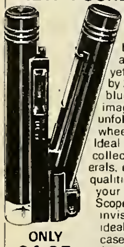

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site of the telescope. The period of the unknown effect was uncertain, but it was more like a year than ten months. It was left for an amateur astronomer and mathematician—in private life a prosperous New England merchant—to crack the puzzle. Seth C. Chandler probably didn't know enough theory to make the usual mistake. He announced in 1891 that Euler's variation was real, but the period was fourteen months instead of ten. This created a furor. As happens even in our day, the theorists were unwilling to believe an observation unless they knew a good theoretical reason for it. They were quick to claim that Chandler's analysis must be faulty or that his observations were bad. They could not imagine that Euler's theory was so wrong.

Nevertheless, the observations and the analysis withstood all attempts to bring them down. Finally, Newcomb found the answer—the earth is not rigid. Euler's theory was not wrong, it just didn't apply to the real earth. Chandler's result was the first observational evidence of the earth's flexibility, and Newcomb's qualitative explanation is still the simplest known.

The speed of a spinning body is controlled by its distribution of mass in such a way that—in the absence of friction—the spin energy remains constant. Every figure skater knows that spin varies and can be speeded up or slowed down as the arms are moved toward or away from the body. Newcomb reasoned that the same principle applies to the earth. If the earth were rigid, there would be no latitude movement, despite the enormous centripetal effects of the equator whirling around at 1,000 miles per hour. Because the earth is flexible, however, the centripetal "force" is not completely balanced by the internal strength until there is an elastic deformation, that is, an increase in the size of the equatorial bulge. This permits some of the mass to move outward. Not only does this slow the earth, like the skater, but it also slows the motion predicted by Euler. We know now that a flexible earth without oceans would show a polar motion with a period of approximately thirteen months. The sloshing around of the oceans lengthens this to fourteen months, Chandler's period. To distinguish this motion of the real, elastic earth from the theoretical motion, it is called the Chandler motion, or the Chandler wobble.

Actually, Newcomb's explanation only provided a cure for faulty intui-

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tion; it does nothing to explain what really happens inside the earth to produce the Chandler wobble. We still don't know. Some theorists believe that there is convection in the earth's core; others are just as convinced that seismic activity drives the wobble.

It is difficult to imagine how convection could produce enough mass displacement to produce the observed polar motion, and this is not a very widely accepted theory. Many more experts consider that the seismic connection is more likely. We are beginning to realize that very massive earthquakes, especially those in tectonic subduction zones such as the fabled "ring of fire" of the Pacific Basin, involve much more displacement of mass than had been previously supposed. This displacement is a possible source of the wobble, equivalent to the motions of the ice-skater's arms. Some correlations between known earthquakes and observed polar motion have been claimed, but the evidence is not ironclad.

Chandler's discovery, once it was accepted as real, meant that theory was no guide to the behavior of the earth. Concerted and frequent observations were necessary to determine the true character of the Chandler wobble. It was still supposed, however, that the real wobble was just as simple as Euler's theoretical motion, so a short observing campaign should suffice. The International Latitude Service (ILS) was established in 1899 for that purpose, with five observatories spread around the world on the same circle of latitude.

Alas, reality is always more complicated than we imagine. The movement of the poles does not simply follow a neat circle with the Chandler period of fourteen months. The observed path looks rather like that of a drunken turtle on a racetrack, and the period is not a simple fourteen months. Certainly, the Chandler fourteen-month period is the most important movement, but there are also annual, semiannual, and random components. The "short" ILS operation is therefore being continued, nearly ninety years after its start, in a greatly expanded program called the International Polar Motion Service.

We now know that the total polar motion is produced by a combination of causes—the Chandler wobble and seasonal variations. Only the Chandler wobble, the fourteen-month part of the motion, is the result of shifts of interior mass, whatever their cause. The sea-

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sonal (annual and semiannual) changes in the earth's motion are the result of impulses imparted to the planet by large-scale atmospheric movements and other seasonal mass transport, such as snow accumulation and vegetation. Significant events of either kind should produce abrupt changes in the size of the wobble.

The cause of the Chandler wobble is still uncertain, but the seasonal variations in the speed and direction of the earth's rotation can be completely explained as effects of the weather.

Leaving its causes aside, does the polar motion have any effect of importance? Certainly, the original, practical interest arose because astronomers and navigators need to know where the earth is in space in order to interpret their observations correctly. More recently, meteorologists have raised a more intriguing idea about the polar motion. About forty years ago a Japanese scientist suggested that the Chandler wobble causes changes in the global climate. He and a few others have continued to investigate this, and the American meteorologist Reid A. Bryson believes that he has found a near-perfect correlation between the polar motion and abnormally heavy rainfall in a particular region of India. While there is no evidence that the correlation is other than accidental or that the degree of wetness in Poona has any connection with worldwide climate effects, still, a possible correlation remains an interesting idea for those who worry about world food supplies.

The Chandler wobble is so small and obscure that few of us are ever aware of it, yet, although the subject is controversial, a few specialists believe it might come to play an important role in the prediction of earthquakes and drought. All one has to do, it is presumed, is measure how the latitudes of places change. If only that were as easily done as said. One cannot observe the Chandler motion or the seasonal variations in polar motion. We can, however, observe the total polar motion. Decoding those observations to decide which part is Chandlerian, which part seasonal, and which part observational error is a ticklish business. At present, specialists do not even agree on whether there is only one Chandler period or two, separated by a few days. Most investigators assume that the annual effect of the atmosphere is of constant magnitude, but a former director of the U.S. Naval Observatory Time Service, one of our monitoring

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agencies, now claims that even this is not true. The only way in which these problems can be resolved is through more accurate observations.

Nearly a century ago, a major concerted effort in geodynamics was begun with the founding of the International Latitude Service. Today, the space program and radioastronomy provide new ways to determine the polar motion with much higher accuracy. We don't yet know the details of the inside of the earth, but geodynamics provides the best promise for gaining more understanding. Astronomy began with the need to predict the seasons for planting and harvesting, related to the grossest motions of the earth. The need for disaster avoidance—navigational, seismic, and agricultural—is now spurring our quest for a deeper knowledge of the structure of our earth, through space-age observation of the tiny details of those motions.

*J. Derral Mulholland, who has advanced degrees in celestial mechanics and astronomy, is research scientist in the McDonald Observatory of the University of Texas at Austin.*

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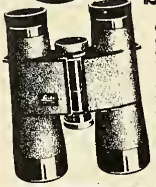

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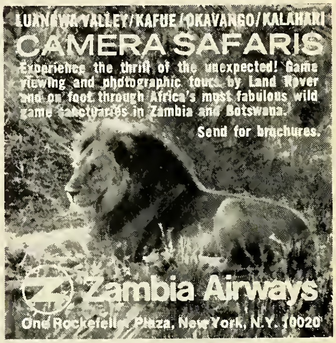

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by Stephen Jay Gould

# Dr. Down's Syndrome

*The term he coined for trisomy-21 is defamatory, misleading, inaccurate, and dead wrong on all counts*

Meiosis represents one of the great triumphs of good engineering in biology. Unless eggs and sperm contain precisely half the genetic information of normal body cells, sexual reproduction cannot work. This halving, or "reduction division," occurs during meiosis when the chromosomes line up in pairs and pull apart, one member of each pair moving to each of the sex cells. The union of two halves by fertilization restores the full amount of genetic information, while the mixing of genes from two parents in each offspring also supplies the variability that Darwinian processes require. Our admiration for the precision of meiosis can only increase when we learn that cells of some ferns contain more than 600 pairs of chromosomes and that, in most cases, meiosis splits each pair without error.

Yet organic machines are no more infallible than their industrial counterparts. Errors in splitting often occur. On rare occasions, such errors are harbingers of new evolutionary directions. In most cases, they simply lead to misfortune for any offspring generated from such a defective egg or sperm.

In the most common of meiotic errors, called nondisjunction, the chromosomes fail to split. Both members of the pair go to one sex cell, while the other comes up one chromosome short. Offspring formed from the union of a normal sex cell with one containing an extra chromosome by nondisjunction will carry three copies of that chromosome in each cell, instead of two. This anomaly is called a trisomy.

In humans, the twenty-first chromosome suffers nondisjunction at a remarkably high frequency. About 1 in 600 to 1 in 1,000 newborn babies carry an extra twenty-first chromosome, a condition technically known as trisomy-21. These unfortunate children suffer mild to severe mental retardation and usually die at a young age (average life expectancy is about sixteen years). They exhibit, in addition, a suite of distinctive features, including short, broad hands; a narrow, high palate; rounded face and broad head; a small nose with a flattened bridge; and a thick and furrowed tongue.

The frequency of trisomy-21 rises sharply with increasing maternal age. We know very little about the causes of trisomy-21; indeed, its chromosomal basis was not discovered until 1959. We have no idea why it occurs so often and why other chromosomes are not nearly so subject to nondisjunction. We have no clue as to why an extra twenty-first chromosome should yield the highly specific set of abnormalities associated with trisomy-21. But at least it can be identified in utero by counting the chromosomes of fetal cells, thus providing an option for early abortion.

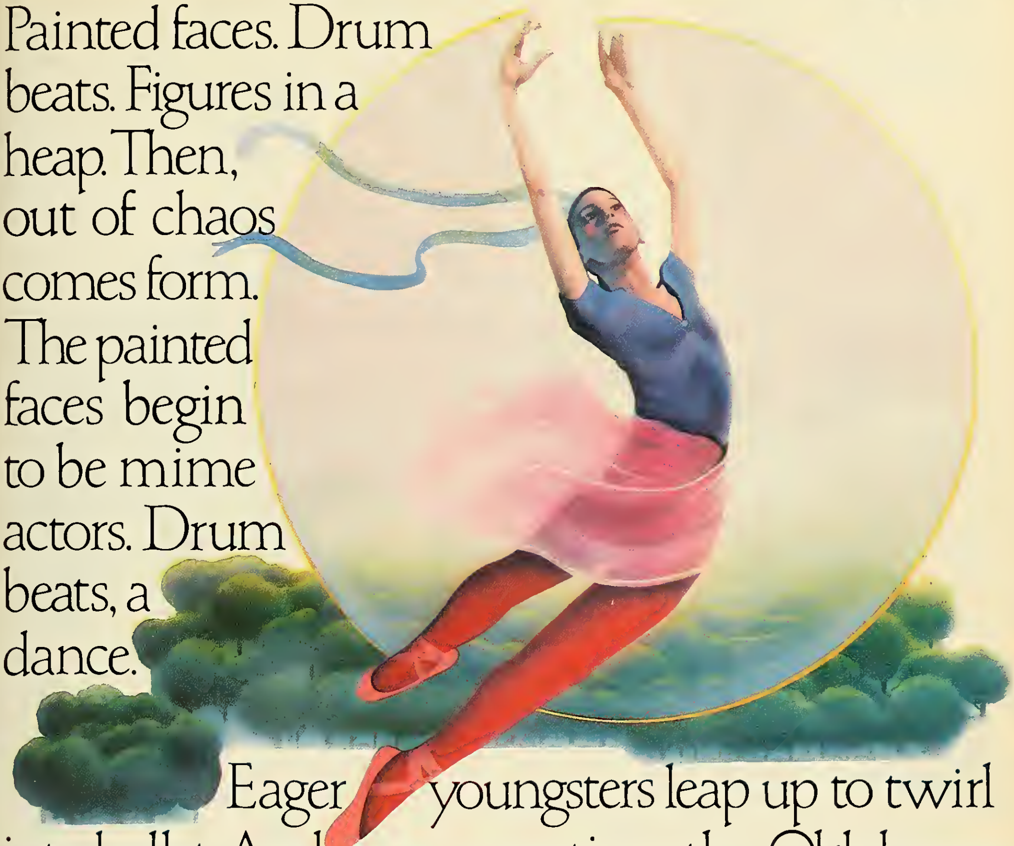
If this discussion strikes you as familiar, but lacking in one respect, I have indeed left something out. The common designation for trisomy-21 is Mongolian idiocy, Mongolism, or Down's syndrome. We have all seen children with Down's syndrome, and I feel certain that I have not been alone in wondering why the condition was ever designated Mongolian idiocy. Children with Down's syndrome can be recognized immediately, but (as my previous list demonstrates) their defining traits do not suggest anything Oriental.

Some, to be sure, have a small but perceptible epicanthic fold, the characteristic feature of an Oriental eye, and some have slightly yellowish skin. These minor and inconstant features led Dr. John Langdon Haydon Down to compare them with Orientals when he described the syndrome in 1866. But there is far more to the story of Down's designation than a few occasional, misleading, and superficial similarities; it embodies an interesting tale in the history of scientific racism.

Few people who use the term are aware that both words, Mongolian and idiot, had technical meanings for Down that were rooted in the prevailing cultural prejudice, not yet extinct, for ranking people on unilinear scales with the ranker's group on top. Idiot once referred to the lowest grade in a threefold classification of mental deficiency. Idiots could never master spoken language; imbeciles, a grade above, could learn to speak but not to write. The third level, the slightly "feeble-minded," engendered considerable terminological controversy.

In America, most clinicians adopted H.H. Goddard's term, "moron," from a Greek word meaning foolish. Moron is a technical term of this century, not an ancient designation, despite the length of metaphorical whiskers on those terrible, old moron jokes. Goddard, one of three major architects for the rigidly hereditarian interpretation of IQ tests, believed that his unilinear classification of mental worth could be simply extended above the level of morons to a natural ranking of human races and nationalities, with southern and eastern European immigrants on the bottom (still, on average, at moron grade), and established American WASPs on top. (Goddard instituted IQ tests for immigrants upon their arrival at Ellis Island. He proclaimed more than 80 percent of them feebleminded and urged their return.)

Down was medical superintendant of the Earlswood Asylum for Idiots in Surrey, England, when he published his "Observations on an ethnic classification of idiots" in the London Hospital Reports for 1866. In a mere three pages, he managed to describe Caucasian "idiots" that reminded him of African, Malay, American Indian, and



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Oriental peoples. Of these fanciful comparisons, only the "idiots who arrange themselves around the Mongolian type" survived in the literature as a technical designation. (I thank Dr. Carolyn Fluehr-Lobban of Rhode Island College for calling this story to my attention, sending me a copy of Down's obscure paper, and generally sharing her thoughts with me.)

Anyone who reads Down's paper without a knowledge of its theoretical context will greatly underestimate its pervasive and serious purpose. From our perspective, it represents a set of flaky, superficial, almost whimsical analogies presented by a prejudiced man. In his time, however, it embodied a deadly earnest attempt to construct a general, causal classification of mental deficiency based upon the best biological theory (and the pervasive racism) of the age.

Down played for stakes higher than the identification of some curious noncausal analogies. Of previous attempts to classify mental defect, he complained:

> Those who have given any attention to congenital mental lesions must have been frequently puzzled how to arrange, in any satisfactory way, the different classes of this defect which have come under their observation. Nor will the difficulty be lessened by an appeal to what has been written on the subject. The systems of classification are generally so vague and artificial, that, not only do they assist but feebly, in any mental arrangement of the phenomena which are presented, but they fail completely in exerting any practical influence on the subject.

In Down's day, the theory of recapitulation embodied a biologist's best guide for the organization of life into sequences of higher and lower forms. (Both the theory and "ladder approach" to classification that it encouraged are, or should be, defunct today. See my book *Ontogeny and Phylogeny*, Harvard University Press, 1977.) This theory, often expressed by the mouthful "ontogeny recapitulates phylogeny," held that higher animals, in their embryonic development, pass through a series of stages representing, in proper sequence, the adult forms of ancestral, lower creatures. Thus, the human embryo first develops gill slits, like a fish; later a three-chambered heart, like a reptile; still later a mammalian tail. Recapitulation provided a convenient focus for the pervasive racism of white scientists: they looked to the activities of their own children for comparison with normal, adult behavior in lower races.

As a working procedure, recapitulationists attempted to identify what Louis Agassiz had called the "threefold parallelism" of paleontology, comparative anatomy, and embryology—that is, actual ancestors in the fossil record, living representatives of primitive forms, and embryonic or youthful stages in the growth of higher animals. In the racist tradition for studying humans, the threefold parallel meant fossil ancestors (not yet discovered), "savages" (adult members of lower races), and white children.

But many recapitulationists advocated the addition of a fourth parallel—certain kinds of abnormal adults within superior races. They attributed many anomalies of form or behavior either to "throwbacks" or "arrests of development." Throwbacks, or atavisms, represent the spontaneous reappearance in adults of ancestral features that had disappeared in advanced lineages. For example, Cesare Lombroso, the founder of "criminal anthropology," believed that many lawbreakers acted by biological compulsion because a brutish past lived again in them. He sought to identify "born criminals" by "stigmata" of apish morphology—receding forehead, prominent chin, long arms.

Arrests of development represent the anomalous translation into adulthood of features that arise normally in fetal life but should be modified or replaced by something more advanced or complicated. Under the theory of recapitulation, these normal traits of fetal life are the adult stages of more primitive forms. If Caucasians suffer developmental arrest, they may be born at a lower stage of human life—that is, they may revert to the characteristic forms of lower races. We now have a fourfold parallel: human fossil, normal adult of lower races, white children, and unfortunate white adults afflicted with atavisms or arrests of development. It is in this context that Down had his flash of fallacious insight: some Caucasian idiots must represent arrests of development and owe their mental deficiency to a retention of traits and abilities that would be judged normal in adults of lower races.

Therefore, Down scrutinized his charges for features of lower races, just as, twenty years later, Lombroso would measure the bodies of criminals for signs of apish morphology. Seek,

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with enough conviction aforethought, and ye shall find. Down described his search with obvious excitement: he had, or so he thought, established a natural and causal classification of mental deficiency. "I have," he wrote, "for some time had my attention directed to the possibility of making a classification of the feeble-minded, by arranging them around various ethnic standards—in other words, framing a natural system." The more serious the deficiency, the more profound the arrest of development, the lower the race represented.

He found "several well-marked examples of the Ethiopian variety" and described their "prominent eyes," "pufffy lips," and "woolly hair . . . although not always black." They are, he wrote, "specimens of white negroes, although of European descent." Next he described other idiots "that arrange themselves around the Malay variety," and still others "who with shortened foreheads, prominent cheeks, deep-set eyes, and slightly apish nose" represent those people who "originally inhabited the American continent."

Finally, mounting the scale of races, he came to the rung below Caucasian, "the great Mongolian family." "A very large number of congenital idiots," he continued, "are typical Mongols. So marked is this, that when placed side by side, it is difficult to believe that the specimens compared are not children of the same parents." Down then proceeded to describe, with fair accuracy and little indication of Oriental features (beyond a "slight dirty yellowish tinge" to the skin), a boy afflicted with what we now recognize as trisomy-21, or Down's syndrome.

Down did not confine his description to supposed anatomical resemblances between Oriental people and "Mongolian idiots." He also pointed to the behavior of the afflicted children: "They have considerable power of imitation, even bordering on being mimics." Some familiarity with the literature of nineteenth-century racism is required to read between these lines. The sophistication and complexity of Oriental culture proved embarrassing to Caucasian racists, especially since the highest refinements of Chinese society had arisen when European culture still wallowed in barbarism. (As Benjamin Disraeli said, responding to an anti-Semitic taunt: "Yes, I am a Jew, and when the ancestors of the right honorable gentleman were brutal savages . . . mine were priests in the temple of Solomon.") Caucasians solved this dilemma by admitting the intellectual power of Orientals, but attributing it to their facility for imitative copying, rather than to innovative genius.

Down concluded his description of a child with trisomy-21 by attributing the condition to developmental arrest (due, Down thought, to the tubercular condition of his parents): "The boy's aspect is such that it is difficult to realize that he is the child of Europeans, but so frequently are these characters presented, that there can be no doubt that these ethnic features are the result of degeneration."

By the standards of his time, Down was something of a racial "liberal." He argued that all people had descended from the same stock and could be united into a single family, with gradation by status to be sure. He used his ethnic classification of idiots to combat the claim of some scientists that lower races represented separate acts of creation and could not "improve" toward whiteness. He wrote:

> If these great racial divisions are fixed and definite, how comes it that disease is able to break down the barrier, and to simulate so closely the features of the members of another division. I cannot but think that the observations which I have recorded, are indications that the differences in the races are not specific but variable. These examples of the result of degeneracy among mankind, appear to me to furnish some arguments in favor of the unity of the human species.

Down's general theory of mental deficiency enjoyed some popularity but never swept the field. Yet his name for one specific anomaly, Mongolian idiocy (sometimes softened to Mongolism) stuck long after most physicians forgot why Down had coined the term. Down's own son rejected his father's comparison of Orientals with children afflicted with trisomy-21, although he defended both the low status of Orientals and the general theory linking mental deficiency with evolutionary reversion:

> It would appear that the characteristics which at first sight strikingly suggest Mongolian features and build are accidental and superficial, being constantly associated, as they are, with other features which are in no way characteristic of that race, and if this is a case of reversion it must be reversion to a type even further back than the Mongol stock, from which some ethnologists believe all the various races of men have sprung.

Down's theory for trisomy-21 lost its rationale—even within Down's invalid racist system—when physicians detected it both in Orientals themselves and in races lower than Oriental by Down's classification. (One physician referred to "Mongol Mongolians" but that clumsy perseveration never took hold.) The condition could scarcely be due to degeneration if it represented the normal state of a higher race. We now know that a similar set of features occurs in some chimpanzees who carry an extra chromosome probably homologous with the twenty-first of humans.

With Down's theory disproved, what should become of his term? A few years ago, Sir Peter Medawar and a group of Oriental scientists persuaded several British publications to substitute Down's syndrome for Mongolian idiocy and Mongolism. I detect a similar trend in this country, although Mongolism is still commonly used. Some people may complain that efforts to change the name represent yet another misguided attempt by fuzzy-minded liberals to muck around with accepted usage by introducing social concerns into realms where they don't belong. Indeed, I do not believe in capricious alteration of established names. I suffer extreme discomfort every time I sing in Bach's *Saint Matthew Passion* and must, as an angry member of the Jewish crowd, shout out the passage that served for centuries as an "official" justification for anti-Semitism: Sein Blut komme über uns und unsere Kinder ("His blood be upon us and upon our children"). Yet, as he to whom the passage refers said in another context, I would not change "one jot or one tittle" of Bach's text.

But scientific names are not literary monuments. Mongolian idiocy is not only defamatory. It is misleading, inaccurate, and dead wrong on all counts. We no longer classify mental deficiency as a unilinear sequence. Children with Down's syndrome do not resemble Orientals to any great extent, if at all. And, most important, the name only has meaning in the context of Down's discredited theory of racial reversion as the cause of mental deficiency. If we must honor the good doctor, then let his name stand as a designation for trisomy-21—Down's syndrome.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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# At the American Museum

## Aura of Feathers

*by Phyllis Rabineau*

Feathers have provided a medium for artists in all parts of the globe over thousands of years. Some featherwork, regarded as wealth because of its beauty, fragility, and scarcity, is associated with high social status. Other objects embody the symbolic connection of feathers and birds with spiritual powers.

An intricate relationship between wealth, status, and spiritual belief is known from traditional Hawaiian culture, where feather costuming was among the most valued possessions of aristocratic chiefs. The feathers were taken from tiny birds, members of several species of honey creeper. They were gathered by professional hunters, who trapped the birds, plucked them, and attempted to release them unharmed. Often only a few feathers were taken from each bird, and their consequent scarcity added to their value. Areas of the islands where these birds lived paid their state taxes in the form of feathers.

The plumage was not merely wealth, however; it was believed to be highly charged with spiritual power, or *mana,* and handling it subjected people to potentially dangerous interactions with this power. Only individuals who themselves had great *mana,* men of high social status, could safely work in feather arts. This work had to be accompanied by religious observances, and the designs on completed pieces were believed to result from spiritual inspirations. High-ranking women could clean and sort feathers and make their own feather necklaces or headbands, called leis. But only aristocratic men could fashion the most valuable objects, such as helmets, cloaks, and shoulder capes.

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**Feather Arts: Beauty, Wealth, and Spirit from Five Continents,** an exhibit of more than 250 feather artifacts, will be on display at the American Museum of Natural History from April 18 through August 31.

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There are several reasons feathers seem charged with spiritual symbolism, but certainly the most important is the special ability of birds—flight. To mankind, bound to the earth and to the everyday concerns of life, flight is a dream motif, a poetic metaphor. In visions, men fly to the heavens, visiting spirits who can use their powers to assure good harvests, cure illness, foretell the future, and vanquish enemies. Flight can also represent a joyous freedom of the soul.

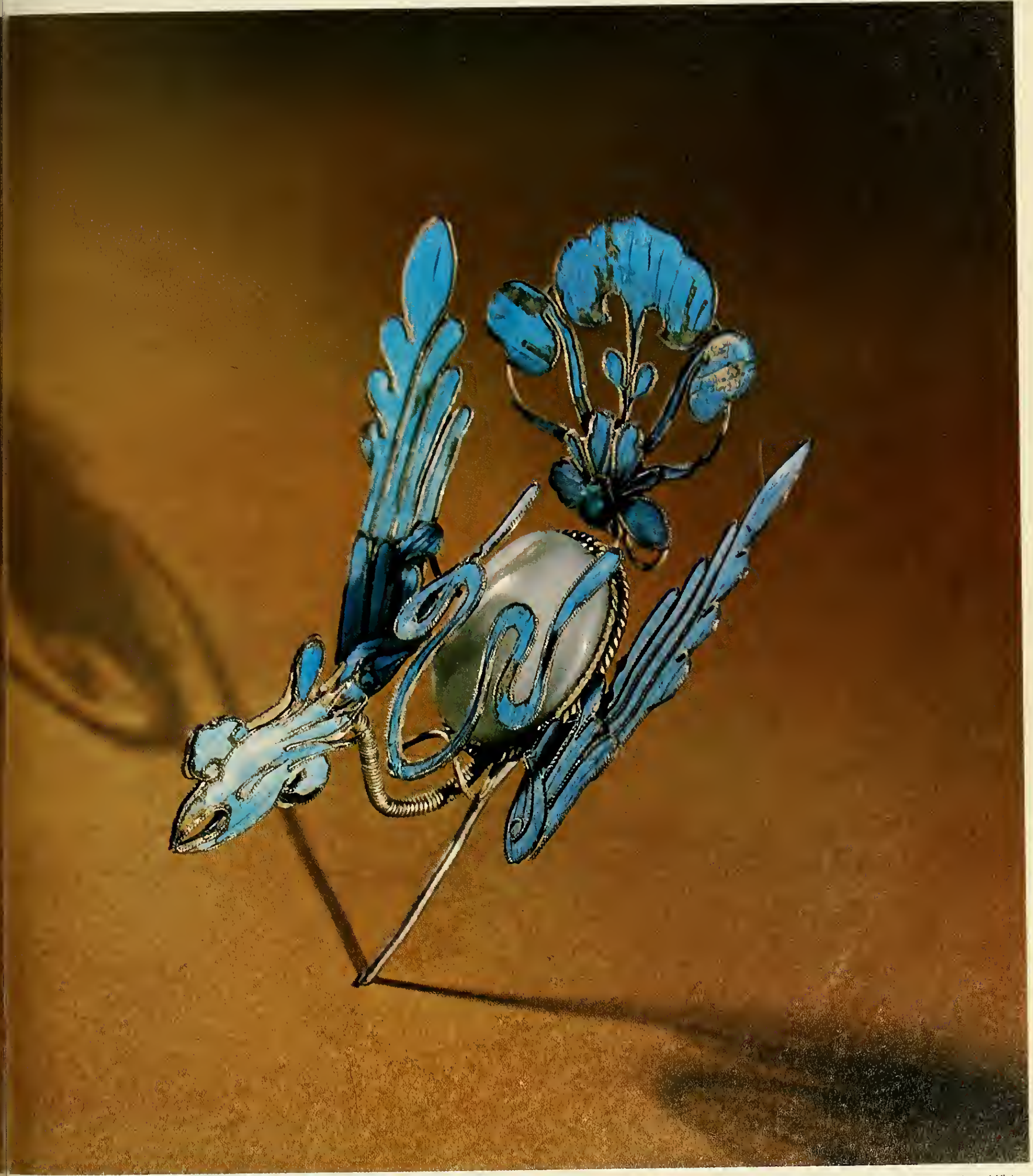
The deeply religious Huichol Indians of Mexico view feathers as prayers for life and decorate many objects with them, especially costuming used on the sacred peyote quest. The Huichol believe that because birds can fly, they know all that happens in this world and the world of the spirits. Their plumes share this power and can convey it to the shaman, a ritual specialist who uses feathers to locate and draw out the source of illness in his patient's body.

The delicacy, fragility, and lightness of feathers are also important symbolic qualities. For example, ancient Egyptians believed that after death the soul was judged by weighing its heart on a balance scale against the feather of truth. If the heart was pure, it would balance; a heart heavier than the feather was burdened with sin and would condemn the soul to hell. Down is especially significant in many North American Indian ceremonies as a manifestation of great spiritual power. A headman's dance from the Pacific Northwest Coast is performed wearing a headdress loosely piled with eagle down. Released by the movements of the dance, the down floats throughout the audience, symbolizing the blessings and spiritual strength of the headman. The fragile substance serves to express the most potent of forces.

In many cultures, feather headdresses may serve as material manifestations of spiritual energy. Many

Excerpted by permission from *Feather Arts* © 1979 Field Museum of Natural History

*Kingfisher feather inlay pin, China*



Photographs by Ron Testa, courtesy of the Field Museum of Natural History

*Eighteenth-century Hawaiian effigy of the war god Kukailimok*

*Pair of Apaya-Kalinga head ornaments, Philippines*

peoples believe that the head is the center of this energy and ascribe special power to the hair. For example, the highland people of New Guinea, in a belief reminiscent of the Old Testament story of Samson, see a man's hair as the locus of his strength. The ghosts of his ancestors live in his hair, and a luxuriant coiffure is evidence of their support. To enhance this strength, the men augment their own hair with wigs, combs, and other ornaments. In Brazil, the shamans of a group called the Tapirapé used a red feather headdress to draw into themselves the spiritual forces of lightning and thunder in a dramatic ceremony during which they struggled to overcome the destructive power of these elements.

Often, the mere form of a headdress suggests spiritual energy radiating from the head, in the manner of halos so well known in Christian and Buddhist iconography. With their shimmering colors and symbolic attributes, feathers are ideally suited for representing this aura.

The behavior of specific birds has also figured in the symbolism of feather arts, and in this respect no bird has been more important than the eagle. Many peoples have used the eagle to symbolize the ideals and accomplishments of their culture and have reserved its feathers for special uses. This symbolism was especially strong among native North Americans for whom the eagle represented both secular and sacred power and often the intermingling of both.

While Plains bonnets are easily the best-known headdresses from North America, many other kinds were made. Some groups used eagle feathers; others chose feathers from different birds of prey, especially owls, which were admired for their stealthy, nocturnal hunting and their frequent association with the powers of sorcery. Another North American bird associated with magic was the jay, with its reputation for mischief and stealing from other birds' nests.

Folk sayings from highland New Guinea compare men to bowerbirds, a family with distinctive mating habits: the male bowerbird builds a complex structure, consisting of a dance platform and viewing area, connected by a gallery of upright stems. Upon the first platform, he performs a courtship dance while the female bird watches from the nearby viewing area. In a similar fashion, the New Guinea men prepare special dance areas in their villages, and bedeck themselves in finery—much of it feathered—to dance in hopes of dazzling and delighting the watching women.

These men say that the physical beauty displayed in their dances is linked with both economic and spiritual factors. The feathers and other decorations are a form of wealth and, therefore, marks of material success both for the individual wearing them and for the kinsmen from whom he has borrowed some of the ornaments. Furthermore, a good appearance is likely to have the magical power to help a man increase his available supply of ornaments and other objects of wealth, and also acquire more wives, who are regarded as a special form of wealth.

Finally, a beautiful appearance is impossible without the assistance of ancestral spirits, who help a man hunt birds for decorative plumage and also help make the plumage look bright. To assure these ancestral blessings, the men observe various religious customs. If these rituals are carried out properly, the spirits will congregate in a man's hair and help him achieve his goals.

*Phyllis Rabineau, custodian of collections in the Department of Anthropology of Chicago's Field Museum of Natural History, is curator of the traveling exhibit* Feather Arts.

# Czar Alexander's favorite rocks

During the month of January, visitors to the American Museum of Natural History may have noticed truckloads of unidentified wooden crates being unloaded at the 77th Street entrance. Inside the crates, nestled in cotton, wadded newspapers, and cloth, were some 40,000 mineral specimens—the largest mineral acquisition the Museum has ever made.

The Museum bought the collection, one of the world's largest, from Columbia University for $500,000, thereby increasing its own collection by 80 percent. The purchase "puts our collection on the map," according to George Harlow, assistant curator of Mineral Sciences. "Big collections like this," Harlow says, "don't come up for sale anymore—they've been gobbled up."

Negotiations for the transaction began last year. According to Wallace Broecker, chairman of Columbia's Department of Geology (which in the last few decades had shifted its research emphasis from mineralogy to other areas of geology), the university felt that a museum would be better able to care for the collection.

Most of the Columbia minerals were acquired in the late nineteenth and early twentieth centuries when many big mines were just being opened. "Today," says Harlow, "you couldn't get some of these minerals at any price—their localities have been cleaned out. The real strength of this collection is its remarkable diversity. There are Russian pieces from the czar; South American, French, African, Canadian pieces—it's all there."

The new acquisition will complement the Museum's present minerals, which were gathered more with an eye to the beauty of the stones than as a systematic collection. The Museum, for example, possesses about 2,500 cut gemstones, including the Star of India, which are beautiful but of lesser interest to scientists than an assemblage of drab clay ores from Africa.

The Columbia collection had been assembled by generations of professorial rockhounds, such as Thomas Egleston, who brought back thousands of specimens from the western United States in the 1850s and 1860s. In 1869, Czar Alexander II traded some of his prized minerals for specimens from Columbia. The university received a two-pound platinum nugget, a cluster of large, deep green emerald crystals flecked with mica, and assorted beryls and topazes. Columbia retained the platinum nugget, but the American Museum now has the rest.

The collection also includes rare uranium ores collected by Prof. Paul Kerr in the 1940s and 1950s, when the first commercial uranium mines were being opened up. Kerr recalls collecting at the Schinkolobwe uranium mine in the Belgian Congo (Zaire) during the early days of World War II. "The green ore piled on the ground," he says, "looked like alfalfa fields. There was a galaxy of rare and unknown uranium minerals. Those ore piles would have made any mineral collector go crazy." From one stockpile destined for the ore crusher, he saved a two-foot-long specimen of moss green torbernite and specimens of jet black uraninite and pitchblende.

Other collectors brought back rubies from Burma, stibnites from Japan, a Kelly smithsonite from New Mexico, and a "peerless" cluster of acanthite crystals from Freiberg, East Germany. During the excavations for the New York City subway system, Columbia collectors dogged the footsteps of the engineers and collected, among other specimens, some beautiful garnet crystals and a rare apophylite with white crystals.

Some of the minerals will replace similar ones in the Museum's Hall of Minerals and Gems, but it will be years before they are put on display. Harlow estimates that it will take at least three years to catalog the collection even if the department buys a computer to aid in the task. When the new quarters of the Department of Mineral Sciences were being built in 1979, the curators allocated space for a large storage area to avoid the warehousing headaches so many other Museum departments were facing. Nevertheless, the size of the Columbia collection will cause storage problems. "We built twenty years of expansion into our new storage area," says Harlow, "but this just about fills it up."

*Douglas J. Preston*

### Masked Dance-Drama

On tour for the first time in the United States, the *Royal Dancers and Musicians from the Kingdom of Bhutan* will perform at the American Museum of Natural History on Sunday, April 27, at 3:00 P.M. in the Auditorium. Wearing intricate masks, dancers will enact scenes from traditional Buddhist legend and Bhutanese folklore. Tickets are $9 for the general public, $5 for members. For information, write the Membership Office.

### Discovery Tours

In January 1981, C. Bruce Hunter, author of several books on ancient Mexican ruins, will lead an archeology tour of the Mixtec and Zapotec sites of Oaxaca, Mexico, and other pre-Columbian areas. Tour participants will also visit the ancient cities of Teotihuacán, Cholula, and Xochicalco. For more information write to Discovery Tours at the Museum.

### Lopsided Brains

The evolution of the brain will be the topic of the fiftieth annual James Arthur Lecture. Norman Geschwind will present *Anatomical Asymmetry of the Brain in Humans and Animals: An Evolutionary Perspective* on Monday, April 7, at 6:30 P.M. in the Auditorium. The lecture is free and open to the general public.

### Tahitian Voyage

In 1976, Ben Finney sailed a reconstruction of an ancient, double-hulled Polynesian canoe from Hawaii to Tahiti—a distance of 3,000 miles. Finney will recount his experience on Wednesday, April 16, at 7:30 P.M. in the Auditorium. He will show slides and films of his voyage and discuss some controversial theories of ancient human migrations. *Hokule'a: The Way to Tahiti* is free to members, $3.00 for nonmembers.

### Alvin Ailey

The *Alvin Ailey Repertory Ensemble* will give a free performance at the Museum on Wednesday, April 23, at 7:30 P.M. in the Auditorium. Tickets will be distributed at the first floor Information Desk starting at 5:15 P.M.

### Films of India

Films by Satyajit Ray and Jean Renoir will be among those shown in the Auditorium on two Saturdays, April 5 and 12, from 1:00 to 4:30 P.M. This free program will feature the lives, religions, and crafts of the peoples of India.

### The Graduates

The Class of 1980 of the High School of Performing Arts will present a free afternoon of dance on Sunday, April 20, at 2:00 P.M. in the Auditorium.

### Golden Opportunity

*It's Gold*, a special exhibition in the Roosevelt Rotunda, will remain open until April 18. Ralph J.T. Bauer of the Museum's Department of Exhibition has been commended for his ingenious design of the free-standing exhibition in which more than a million dollars' worth of gold is displayed.

*etail of feather headdress for an Uruba man, Brazil*

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**by James Roy MacBean**

# Documenting People and Places on Film

*"Odyssey," a twelve-week television series on anthropology and archeology. Executive producer Michael Ambrosino. To be shown nationally on the Public Broadcasting Service (PBS), beginning Sunday evening, April 6, at 8:00 P.M., EST (check newspapers for local time).*

Over the past decade there has been growing interest, both professional and popular, in the development of "visual anthropology." While the surge of popular interest may be relatively new, it should be pointed out that various forms of visual anthropology have been around for some time.

One hardly needs to be reminded that Margaret Mead's use of film dates back to her collaboration with Gregory Bateson in Bali in the mid-1930s. Franz Boas, who was influential in bringing so many innovations into the mainstream of American anthropology, was also an early experimenter with the uses of photography and film for anthropological fieldwork and archival research. And one must not forget the remarkable work of another pioneer , Edward Curtis, whose many paintings, drawings, photographs, and films of North American Indians represent a treasure-trove of visual anthropology.

Interestingly enough, both Boas and Curtis, working separately, perhaps even in professional rivalry with each other, happened to shoot quite a bit of film footage of the same Indian tribe, the Kwakiutl of the Pacific Northwest. Their respective ways of using film—revealing very different attitudes toward the medium, the tribal peoples, and the audiences for whom the films were intended—are among the many fascinating issues explored by a provocative new film on the life and work of Franz Boas, the man often called the father of American anthropology. Entitled *Franz Boas (1858–1942)*, the film is one of the highlights of the new television series "Odyssey." This series was put together by executive producer Michael Ambrosino, who also created the highly acclaimed science series "NOVA."

In "Odyssey" the focus is on anthropology and archeology, and while these two disciplines are closely related, they do not seem to be equally suited for treatment in the film and television media. Having previewed most of the series, I have to report a split verdict, with the programs on archeology being downright dull at times (the program entitled *Other People's Garbage*, for example, is utterly devoid of interest, except briefly in the section on excavating slave quarters on a South Carolina cotton plantation). On the other hand, the six programs devoted to anthropology display a rich variety of filmic approaches to a rich variety of subject matters and are consistently excellent.

Fortunately, the superior quality of the anthropology half of "Odyssey" more than makes up for the deficiencies of the archeology side. With the exception of the film portrait of Boas, the anthropology programs consist of ethnographic film studies that explore various tribal cultures from around the world. Of the five ethnographic films,

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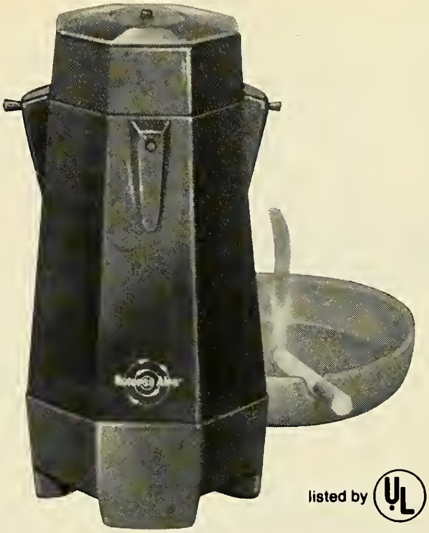
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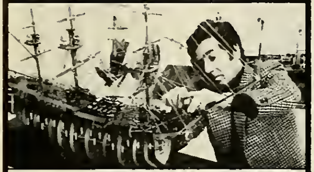

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three were originally produced in Great Britain by Granada Television for a British series called "Disappearing World."

Broadcast on British television in the mid-1970s, the "Disappearing World" impressed both professional circles of anthropologists and filmmakers and the general television audience. There was an immediacy and an authenticity in these films that enabled professional and popular audiences alike to come away feeling that they had not only learned something about other cultures but that they had also learned from the *inside*, as it were, by getting close to the everyday lives of individuals.

This, indeed, was the goal of Brian Moser, who created the series. Moser wanted as much authenticity as possible; he wanted to avoid the glib superficiality or outright falsification that can occur when a globe-trotting film crew flies in, shoots from the hip, and flies out a few days later. Moser conceived of each film as a collaborative effort in which anthropologists and filmmakers would work together as equals and share in the overall conception of the films. Moreover, each project was planned to allow the anthropologist-filmmaker team sufficient time *in the field* to shoot their film over many months of day-to-day interaction with the tribal peoples.

The high quality of the finished films in the series demonstrates the wisdom of Moser's approach (although the title "Disappearing World" was a most unfortunate choice, full of rather dubious ideological connotations, and one that several anthropologists refused to be associated with). But most importantly, the overall success of the series proved that visual anthropology can be good anthropology and, at the same time, good entertainment of a high artistic and intellectual order.

Although Michael Ambrosino's current "Odyssey" series for American public television is hardly as innovative—or as successful on the whole—as "Disappearing World," it does offer, among other things, three of the most interesting films from the British series. The first of these to be shown (May 11) is *Ongka's Big Moka*, a joint creation of producer-director Charlie Nairn and anthropologist Andrew Strathern. It is a fascinating study of the efforts of a "big-man," or man of authority, in the New Guinea highlands to organize his relatives and tribesmen in a large, complex political alliance system, the formation of which depends on, and is publicly sealed by, the giving of a huge gift, or *moka*, comprised of pigs, ornamental shells and feathers, cash, and various other forms of wealth.

To be shown later in the series are *Masai Women* (May 25) and *The Sakuddei* (June 22). One of the most highly acclaimed of the earlier British series, *Masai Women* is a product of the collaboration of producer-director

*Children in* N!ai, the Story of a !Kung Woman, *a film about the Bushmen of the Kalahari*

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I rented a P.O. Box in Kent and placed a small ad. It was surprisingly cheap.

Several weeks later I stopped by the post office. I walked over to my box. When I looked through the little glass window on the door, I almost dropped my key. The box was stuffed—jammed —full of letters. All of them contained checks for $3.98—and they'd come from all parts of the U.S. and Canada.

The next few days were hectic, to say the least. My wife typed the recipes. I had them duplicated, stapled them together and our crude little book was born. But, every day, orders continued to pour in. And every day we'd bank the money and send out our stapled recipe booklet.

I decided to try another ad. This time I placed a classified ad for some of my beer and wine making recipes in Popular Mechanics. Again, the orders poured in. Over $1,000.00 in just several weeks. And, as our business grew, I corresponded with other people . . .

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- An Oregon man informed me he had made over $14,000.00 selling his small booklet about getting rid of moles and gophers in your yard. Again . . . all by mail.
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Christopher Curling and anthropologist Melissa Llewelyn-Davies. Through a combination of voice-over commentary, direct interviews with tribal women, and several scenes of vivid interaction among the Masai themselves (with English subtitles of the Masai dialogue), this film provides a sensitive insight into how these women feel about their roles in a society where all prestige and property are the exclusive domain of the males.

Also included are two ethnographic films that are not from the British series—*Cree Hunters of the Mistassini*, a Canadian production that follows the Cree Indians as they fly north in winter to spend several months on their traditional hunting, trapping, and fishing territory (to be shown June 8); and the long-awaited release by John Marshall of a new film on the Bushmen of the Kalahari (which will be seen April 13). Marshall compiled this new film, called *N!ai, the Story of a !Kung Woman,* out of footage that spans three decades and was shot in the course of seven major expeditions by the Marshall family to study the !Kung Bushman tribe.

An ethnographic film with a thirty-year time span is absolutely unprecedented. The picture of social change that emerges from *N!ai* should shake up some of the dominant notions in anthropology, especially that of "the ethnographic present," a euphemism that all too often functions as an excuse to avoid the present entirely, to eliminate or ignore any signs of social change over time in favor of narrow-minded concentration on whatever can be found—or "reconstructed"—of the old, "traditional" culture.

An extreme and touchingly naïve example of this romantic, nostalgia-oriented approach to anthropology is provided by the revealing photograph of Franz Boas at work in Ted Timreck's marvelous film-portrait, *Franz Boas (1858–1942)*, to be shown April 20. The photograph shows Boas setting up a scene in which his Kwakiutl Indian subjects, in traditional garb, are ostensibly demonstrating a particular aspect of their traditional culture. But this photograph reveals that Boas is holding up a huge curtain to block the modern picket fence and painted two-story frame house that stands just behind his staged scene of "traditional" Kwakiutl culture.

Indeed, one of the many issues explored insightfully in this rich,

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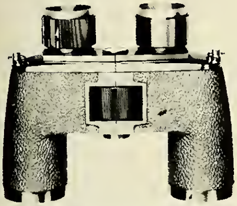

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multilevel film on Boas's life and work is precisely the question of *how* anthropologists collect, use, and conceptualize the visual data they obtain. Ted Timreck has found film footage of Kwakiutl dances that were staged and shot by Boas, who then cut the footage up into individual frames, marked them, and handed them over to an artist whose task it was to make drawings and maquettes for later use in preparing dioramas. And Timreck has also found, and included in *Franz Boas,* some wonderful photographs of Boas modeling various traditional Kwakiutl hunting, dancing, and ceremonial gear. Such photographs ultimately tell us more about Boas the man, Boas the actor, Boas and his extreme identification with the tribal peoples he studies, than they tell us about the Kwakiutl.

But that is all part of the picture, if I may play with words here, of how anthropologists work with visual data. The important thing to keep in mind—and something that separates anthropology from archeology—is that in anthropology there is significant work being carried out in the visual media—film, video, and still photography. In the case of ethnographic film, for example, we who watch the film can share in the excitement and discovery that accompany actual fieldwork in progress, fieldwork being carried out in the very film we are watching.

In archeology, on the other hand, apart from aerial photography or underwater filming (one "Odyssey" program shows the recovery of material from a sixteenth-century Spanish armada warship that sank off the coast of Scotland), little work is carried out through film, video, or photography. These visual media may indeed be used to document work that was originally done by other means, but what we then get—and the "Odyssey" programs on archeology give us more proof of this than we need or want—are illustrated lectures. And these illustrated lectures are particularly deadly when, as in *The Chaco Legacy* (June 1), they are slickly spiced with endless panning shots of picturesque ruins at sunset, and with celestial choirs providing metaphysical mood music on the soundtrack.

*James Roy MacBean teaches film at Rutgers University, where he is coordinating efforts to establish a research institute in film studies. A noted critic, MacBean is the author of* Film and Revolution.

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# Morel Victory

*Nostalgia as well as mushrooms is the object of the Boyne Hunt*

Photographs by Adelaide de Menil

### by Raymond Sokolov

When Gerald Ford was president, certain Washington wags predicted that he would fire the White House chef and bring in someone from his hometown of Grand Rapids who knew how to cook the cuisine of Michigan. Not particularly a fan of Ford, I was nonetheless stung to hear the food of my natal region so scurrilously dismissed as a gastronomic nullity. True, Michigan could boast no local dishes worth matching against Louisiana gumbos or Key lime pie, but we had raw materials second to none: Lake Superior whitefish and Traverse City cherries. Come to think of it, Michigan was also the best place in the country to find a delicacy that even the White House chef, a Frenchman whom Mr. Ford wisely did not dismiss, would have been delighted to present to the most discriminating international guests. Morels.

Morels are generally conceded to be the most delicious of all mushrooms. But they are hard to find in most areas and fruit for only a few short days in the spring, usually in May. Also, no one has ever succeeded in cultivating morels. The true gourmet will never pass up an opportunity to eat their distinctively pitted, furrowed caps.

On my most recent trip to France, which took place providentially in May, the giant asparagus was in season, but I needed no special encouragement to opt, at the legendary Restaurant de la Pyramide in Vienne, for a first course of morels and cream in puff pastry. The *patronne* must have employed a small army of people to scour the woods for all the morels she served that Sunday. Morels camouflage themselves brilliantly in leaves and underbrush. Stands of oak, tulip poplar, and old elms, abandoned apple orchards and burned-over fields are all likely places to look, but no set of conditions is guaranteed to produce morels, and they often pop up singly rather than in bevies. At least they do seem to grow in the same places year after year.

Once, taken to proven morel sites in Rockland County, New York, I came away with four pounds, a gift from the forest worth, to me, its weight in caviar. And so I felt confident that I could hold my own with the mycophiles who assemble each May at Boyne City, Michigan, for the National Mushroom Hunting Championship.

That the woods around Boyne City were full of morels was obvious even to the casual motorist driving north from Detroit. At the Sugar Bowl Restaurant in Gaylord, the jumping-off place for the northern Lower Peninsula, morels were a "special" on the menu. We were only a few miles from Boyne City now, and farmers' mailboxes had mushroom signs on them to show they had morels for sale. At other times of the year, residents of this hilly, wooded region might vaunt its ski slopes or its lakes or remind you that Ernest Hemingway came here as a boy on vacation from Oak Park, Illinois, and later wrote about the area in his Nick Adams stories. But in mid-May, the morel is king in the Boyne Valley.

In Boyne City itself, on the morning of the first day of the two-day championship, a banner over the main street welcomed contestants. The marquee of the Boyne River Inn said: "Have a Mushroom Burger." Nearly every store window had been painted over with mushroom scenes, and children had worked botanically accurate morels into brightly colored cartoons featuring Big Bird, the Cookie Monster, and Snoopy. One precocious youngster executed a faintly risqué window painting and captioned it: "Boyne City has Wild-n-Crazy Morals."

The hoopla didn't stop there. At the registration area manned by the Boyne Valley Lions and the Chamber of Commerce, there were mushroom T-shirts and stationery for sale. A small carnival midway was opening as contestants from all over the country lined up at 7:00 A.M. to get their official numbers and paper collecting bags. Then there was a motor parade of con-

testants through the town and on out to the secret hunting grounds.

Some 200 cars snaked their way to a remote road that ran past farms up to the edge of a woods. Here, we all piled out and waited for the starting signal. Most of the contestants were outsiders. Only about twenty-five people were local, and they had to compete in a separate division because they knew the territory too well. Dana Shaler, a young millwright from nearby Advance, had won twice before in the local division. The rest of us were mainly first-timers.

"I would say 90 percent of the people come to say they've been in a national event," said Bud Bates, one of the organizers of the contest. He was quick to point out that participants have come from as far as Hawaii and Alaska. But, he added, most come from Ohio and Michigan. And when you stop to talk to the contestants, it is clear that they have more on their minds than the tinny luster of winning a hokey national contest.

Homer Syfert, 77, who worked in the Detroit Post Office for thirty years before retiring, has been coming to the Boyne hunt for the past ten years. He has made it to the finals nearly every year but has never won. His interest in mushrooms goes back to his boyhood on a farm south of Decatur, Illinois. "I once picked eleven bushels," he said. "My father told me which ones to pick. You have to look on hills facing south. In Illinois, there were more woods then. All our neighbors ate mushrooms."

Paul Whipple also grew up on a farm—in Michigan—and learned how easy and safe it was to pick morels. Today, he works as a painting contractor in Muskegon, Michigan, but during the season he drives north more than a hundred miles and spends three days foraging for mushrooms that he will parcook, freeze, and eat for the rest of the year. For Whipple, and many other entrants in the National Mushroom Championship, the contest is in large part just an excuse to relive their youthful involvement with mush-

rooms. Poised and ready to charge into the Michigan woods, they are hoping to win some public acclaim for a vestigial skill learned as part of an agricultural, postfrontier Midwestern upbringing.

To the outsider, who had always thought of morels as part of a sophisticated European culinary world, it was a surprise to discover that this American heartland tradition of mushrooming centered almost exclusively on the elusive members of the morel genus, *Morchella*. But as with most folk traditions this one has a pragmatic logic behind it.

Midwestern woods, like all woods, teem with hundreds of mushroom varieties, many of which are toxic or inedible. Morels, however, are delicious and safe, virtually foolproof. Because they fruit so early in the season, there are almost no other mushrooms around to confuse them with. And morels don't even look like classic mushrooms. They have neither gills nor pores. Their cone-shaped caps are pitted or ridged. Once you have seen one, or even a picture, you can never mix them up with anything else, except possibly the false morels, which have wrinkles, not pits or ridges. Also, the cap of the true morel is attached directly to the stalk, whereas the head of the false morel is attached only at the top and hangs down over the stalk like a skirt. It is the case that one true morel, *Morchella semilibera*, is only partially attached, but the exterior of its cap is ridged in the same way as other true morels. In any event, a look at the photographs in a mushroom field manual will make positive and safe identifications a simple matter, as simple as they were for farm folk in Michigan and Illinois earlier in the century.

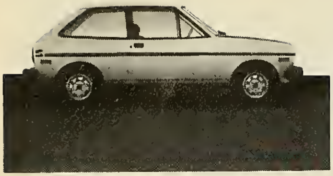
When Homer Syfert was growing up, his family and their neighbors were too cautious to attempt foraging for other kinds of mushrooms that required more sophisticated knowledge. They had the sense to know the limits of their mycological information, so that what they didn't know didn't hurt them. They were certain, however, that *Morchella* looked different from "ordinary" mushrooms even if they didn't realize that it belonged to a special class of fungi, called ascomycetes, whose spores are produced in a microscopic saclike cell called an ascus. (Most of the mushrooms in the woods are basidiomycetes, fungi whose spores are found on spinelike projections, or basidia, on the outside of a club-shaped cell.)

The Syferts and the Whipples did know, however, that true morels are hollow and should be sliced in half lengthwise, examined for insect infestation, and then thoroughly rinsed to remove sand or dirt. They did not have to be reminded not to use plastic collecting bags—plastic causes morels to wilt almost immediately—because there weren't any in those days. But they did master the simple technology of morel preservation.

Drying is probably still the best way, and you can do it most easily in a fruit and vegetable dehydrator. Barring that, spread the morels out in an oven set at the lowest temperature, with the door open, and leave them there until they are crisp. Store in jars in a cool dark place. Reconstitute by soaking one cup of mushrooms in two cups of hot water for thirty minutes. You can also sauté morels in butter until all moisture has boiled away and then freeze them with decent results.

This kind of morel lore was easy to come by as one waited for the contest to begin. Morel hunters are basically generous with information. But once the actual competition began, once we had all run uphill into the woods, it was every man and woman for himself and herself.

Ninety minutes later, breathless from the chase, I returned to the starting line with a slim but still precious bag of fifteen morels. Others had hundreds. I didn't survive the cut and had to sit out the finals the next day, when Paul Whipple won the outsiders' title



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with 309 mushrooms and Dana Shaler copped the local division championship with 445.

That is a lot of morels, but contest veterans were quick to remind us that the highest total in previous years was well over 900, and that the largest single mushroom ever found in the state—10½ inches tall and weighing 14 ounces—would have dwarfed any mushroom picked that day.

Even so I was impressed with the superior skills of the winners, impressed until I stopped on the way south at a farm with a roadside mushroom sign. A little girl led me into a garage filled with bushels of morels. She had collected them after school and on weekends, just as generations of Midwesterners have done before her. "I know where to look," she explained nonchalantly. For her and a few other farm children in the Boyne Valley, the National Mushroom Festival was irrelevant. In their world, what matters is that the woods are still able to produce their bounty—and their parents have shown them where to look for it.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

**Morel Soufflé**

(Adapted from *Morel Mushroom Cookbook*, by Betty Ivanovich, R-B Food Products, 7626 Auburn Road, Utica, Michigan 48087)

½ pound morels, chopped
4 tablespoons butter, approximately
Heavy cream
3 tablespoons flour
Salt
Pepper
4 egg yolks
5 egg whites, beaten until stiff but not dry
Bread crumbs

1. Sauté the chopped morels in 3 tablespoons of the butter for 5 minutes. Meanwhile, butter the inside of a soufflé dish and set aside. Preheat oven to 375 degrees.
2. Remove mushrooms from pan with a slotted spoon, draining juice thoroughly back into pan. Reserve mushrooms.
3. Measure the cooking liquid in the sauté pan. Add enough heavy cream to make ¼ cup liquid. Pour this mixture back into the pan. Add the flour. Heat, stirring constantly, until the mixture reaches the boil. It should be smooth and thick.
4. Remove flour mixture from heat. Stir in salt and pepper to taste and continue stirring until cool.
5. Add mushrooms to cooled mixture. Stir in egg yolks, one at a time, mixing until well incorporated.
6. Fold in egg whites and pour soufflé batter into buttered soufflé dish. Sprinkle lightly with bread crumbs. Dot with butter. Bake for 30 to 35 minutes, or until the top springs back when touched lightly.

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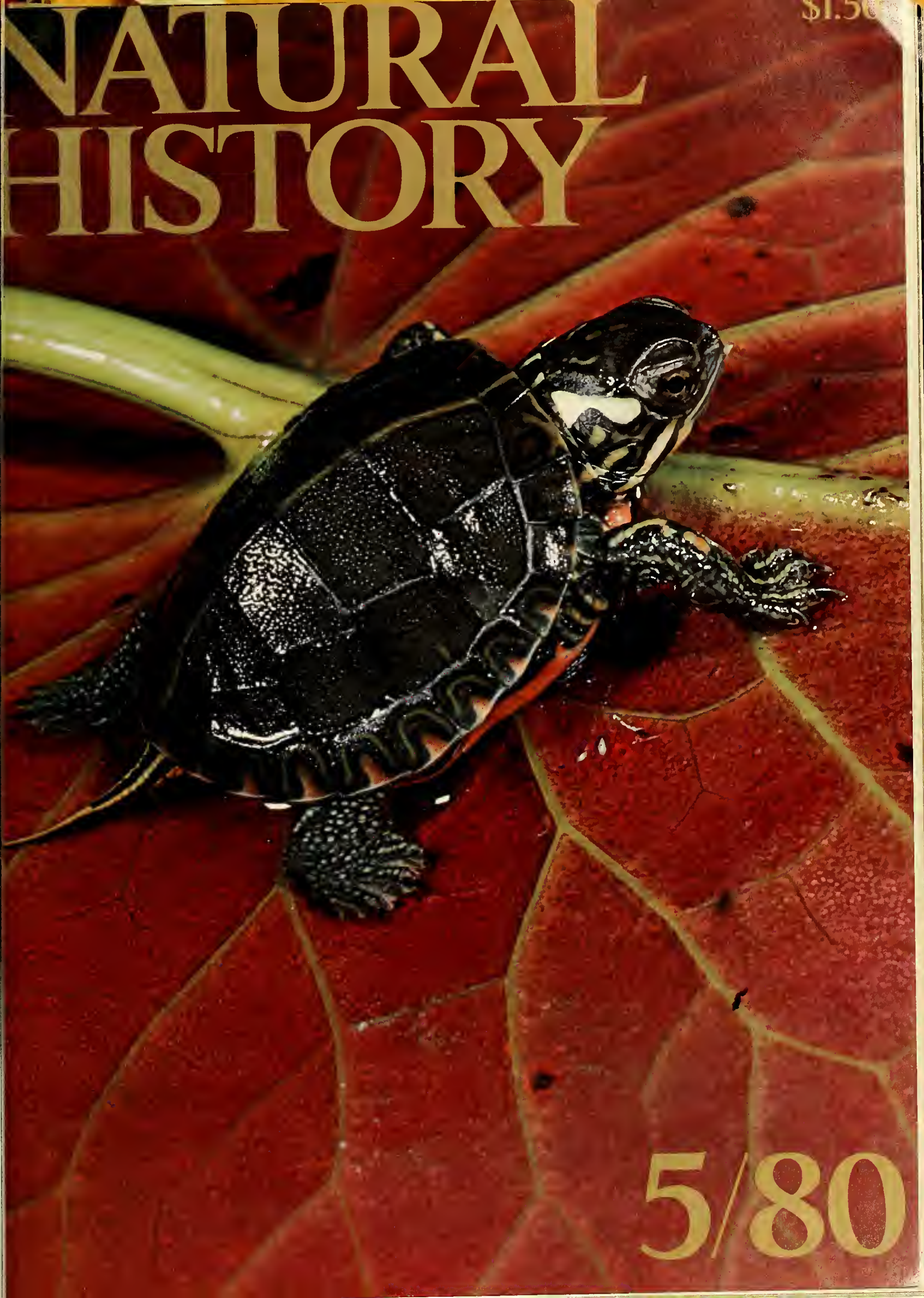

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**Keith Kennedy**, left, was invited to Mackinac Island in 1977 to look into an outbreak of *Lecanium* scale, a fruit tree pest. He soon realized that he had "stumbled onto a 'textbook' example" of how a chemical used against one pest (in this case flies) can indirectly cause an outbreak of another pest. An assistant professor of entomology at Michigan State University, Kennedy now devotes his research to scale outbreaks in urban environments, several of which have occurred in Michigan because of fly- and mosquito-spraying programs.

Uncovering the solution to the Mackinac Island insect problems, according to coauthor **Richard W. Merritt**, required not only study but also the consumption of "mass quantities of Mackinac Island fudge," one of the resort's claims to fame. Merritt, an associate professor of entomology at Michigan State, is primarily interested in aquatic and semiaquatic insects of streams and flood plains, although the dung-breeding flies of Mackinac Island were well within his experience. His graduate work was an ecological study of the insects associated with cattle droppings.

**Don Moll** grew up along the banks of the Illinois River in Peoria, Illinois. He spent much of his boyhood fishing, swimming, and collecting "critters" in the river. Along the way, he developed a strong interest in the ecological changes that brought the river from its former pristine condition to its present polluted state. An assistant professor of ecology and vertebrate zoology at Southwest Missouri State University, Moll's fascination with turtles led him to combine his two interests in a study of how the river's turtles have fared through a century of change. Fieldwork on turtles runs in the family. Moll's brother, Edward, published an article on Malaysian turtles, "Drummers Along the Perak," in the May 1978 issue of *Natural History.*

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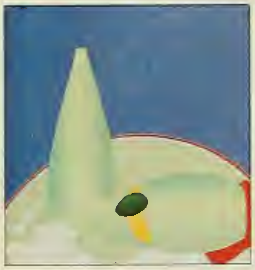
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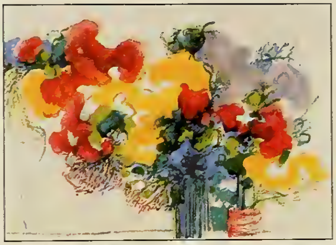
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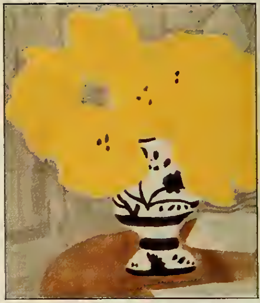
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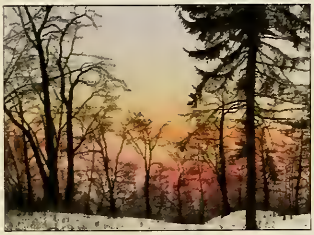
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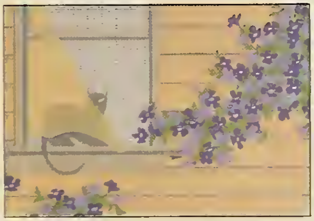
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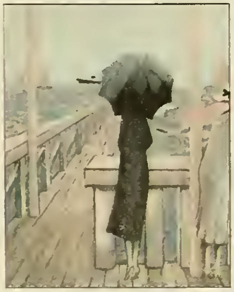
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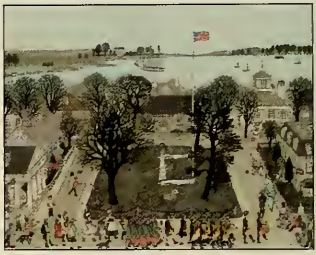
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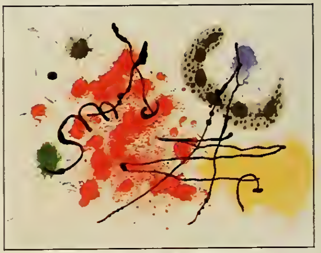
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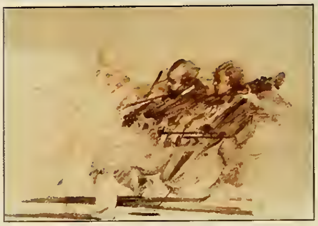
Claude Weisbuch's *Le Trio,* original lithograph.
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For the last decade, **John Bockstoce** has spent nearly six months of each year in arctic Alaska carrying out ethnographical and archeological research on various aspects of Eskimo whaling. His work sites have included the Seward Peninsula, Point Hope, Point Barrow, Cape Nome, Saint Lawrence Island, and Herschel Island and Resolute Bay in Canada. He is currently directing a historical study of Alaskan whaling and fur-trading shipwreck sites for the Alaska Department of Parks, and also continuing his research on commercial whaling and walrus hunting in the Bering Strait region and the Arctic Ocean. Bockstoce is curator of ethnology at the New Bedford Whaling Museum in Massachusetts.

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## A Plethora of Pox Viruses

Five years ago in "The Dubious Gamble Against Smallpox" (August/September 1975) Pascal J. Imperato took a somewhat skeptical look at the efforts to eradicate smallpox. This month (to the delight of Imperato and everyone else), the World Health Assembly is due to announce formally that smallpox has been eradicated from the earth. The news has been out unofficially since last fall, when the last strongholds of smallpox in Africa were confirmed to have been free of the disease for two years.

Imperato wrote about the logistical difficulties of tracking down every last case of smallpox (he directed a smallpox eradication program in west Africa for six years), and he also discussed some of the questions about the nature of the disease that have continued to interest researchers.

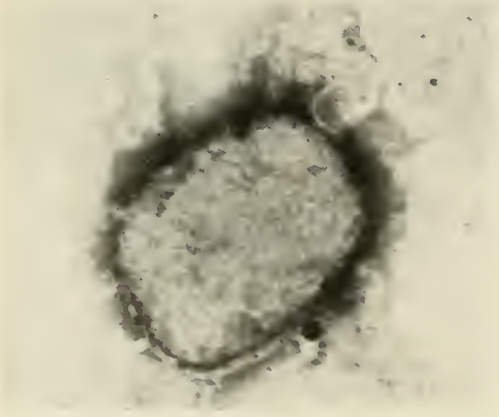
Could there be an animal reservoir of smallpox, he asked, from which the virus might reemerge to infect human beings? Might any of the various animal pox viruses turn out to be variants of smallpox that could be transformed into smallpox itself (variola)? The latter question became particularly pointed when Russian scientist S.S. Marennikova reported in 1978 and 1979 that starting with a monkeypox mother strain and growing it on a chick embryo membrane or in hamsters, she was able to come up with something indistinguishable from smallpox. It was already known that monkeypox on rare occasions infects human beings, although it seldom spreads from one person to another.

Now, Frank Fenner, of the Australian National University and chairman of the WHO's Global Commission for Certification of Smallpox Eradication, says that the evidence has accumulated to the point where it is clear that Marennikova's virus could not have come from monkeypox. Other investigators have failed to duplicate her work, and genetic mapping of the pox viruses has shown that monkeypox and smallpox are, in effect, stable, distinct species. One cannot be transformed into the other by one or even several mutations.

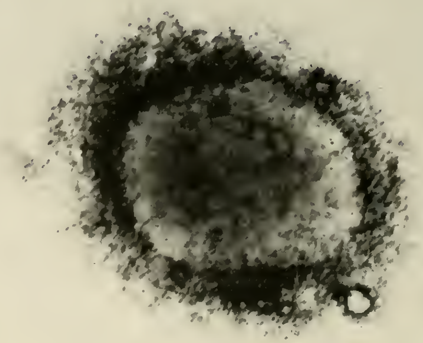
As to whether smallpox can maintain itself in animal populations, there is strong evidence against this possibility. Donald A. Henderson, dean of the School of Hygiene and Public Health of Johns Hopkins University, and formerly in charge of WHO's efforts against smallpox, points out that there has never been an outbreak of the disease that was not traced to human sources. If there were animal reservoirs, untraceable outbreaks would be expected. And, of course, there have been no new eruptions of smallpox in the past two years.

On the other hand there are the confusing reports of the discovery of "whitepox" in animals. Six such incidents have occurred, four reported by Marennikova. Whitepox is a puzzle; it is indistinguishable from smallpox in laboratory tests. Dr. James Nakano of the Center for Disease Control in Atlanta, head of the WHO Collaborating Center for Smallpox and Other Pox Virus Infections, says we "really don't know" what whitepox is or where it comes from. Henderson points out, however, that "in each instance in which whitepox was isolated, work was proceeding in the same laboratory with smallpox. Thus, it is impossible to state with certainty that these whitepox isolates do not represent contaminants."

Imperato, now chairman of the Department of Preventive Medicine and Community Health at Downstate Medical Center in Brooklyn, New

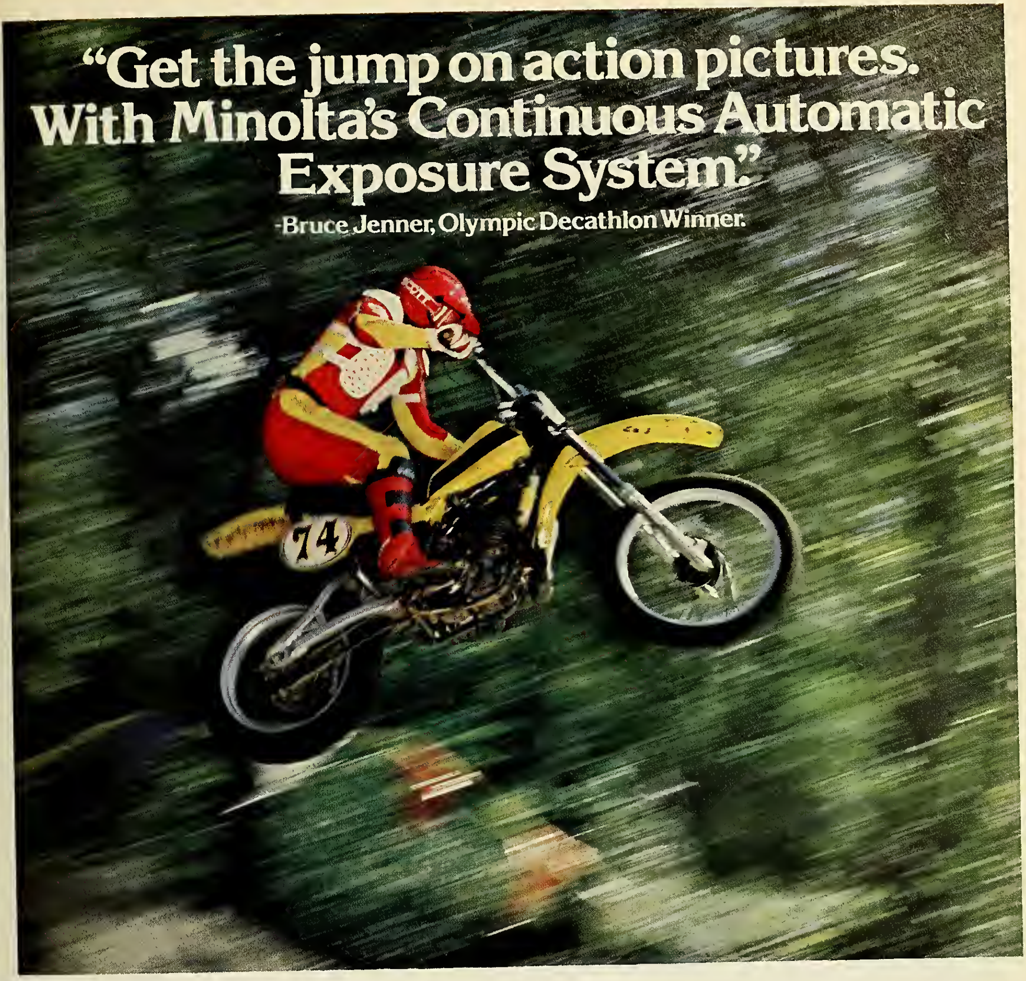


*Smallpox virus*



*Monkeypox virus*

James Nakano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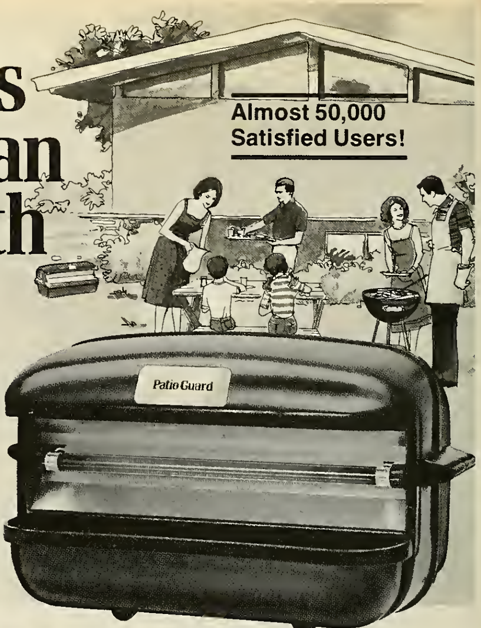

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York, reports that he is encouraged by the lack of untraceable outbreaks of smallpox and by the lack of good evidence for animal reservoirs, but says that some viral diseases spend long periods of time in animal populations before reemerging and that more time in a smallpox-free world is needed to lay to rest definitively the possibility of an animal reservoir of the disease.

## Electricity in Lampreys

Salamanders have the enviable ability to regenerate amputated limbs. In "Skin Batteries and Limb Regeneration," October 1977, Richard Borgens wrote that the source of this electrifying skill was, indeed, electricity.

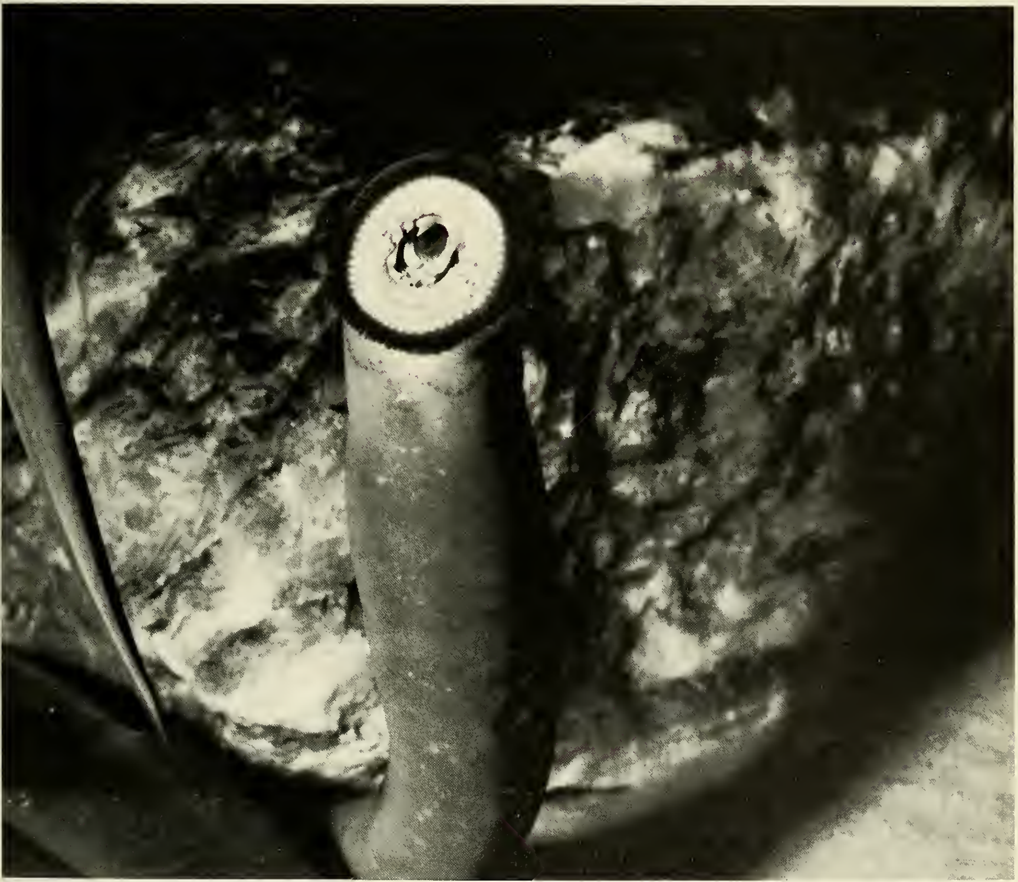
The salamander's skin, it seems, is a kind of battery; in transporting positive sodium ions into the body, it generates an electric current. When Borgens changed the makeup of the water salamanders lived in or used chemicals to block sodium transport, he was able to turn off the battery and disrupt limb regeneration.

Borgens has now turned to the larvae of the sea lamprey, a primitive vertebrate that can partially regenerate its spinal cord when it is severed. Borgens, and his coworkers at Yale, Lionel F. Jaffe and Melvin J. Cohen, discovered currents of up to half a milliampere entering the cut surface of lamprey spinal cords immediately after they were severed (the currents declined after that). A current of this level, channeled through the proper resistance, could power one of the light-emitting diodes used in hand held calculators.

That does not mean, says Borgens, that lampreys are an answer to the energy crisis. But the currents are the largest steady biological currents that have been observed in association with development or injury. And the experiment, reported in the February issue of the *Proceedings of the National Academy of Sciences*, offers some hints as to the biological effects of the currents.

Most of the current is caused by the flow of sodium ions; calcium ions may also play a part. Previous research has shown that some of the processes associated with elongation in cells are under ionic control. The currents may also produce a strong enough electric field to cause the migration of cellular bodies such as mitochondria, which tend to aggregate in the area where the cord has been severed.

*James Gorman*



*Adult sea lamprey*

Russ Kinne, Photo Researchers

# Malaria Safari

*From Kenya to New Jersey, from liver to bloodstream, a victim traces the course of drug-resistant malaria*

**by Richard Van Gelder**

On Sunday, March 12, 1978, the American Museum of Natural History's Kenya safari was camped in tents along the Galana River in eastern Tsavo National Park. Before breakfast, some of us went on a long drive along the river's edge, where we had lovely views of graceful, long-necked gerenuks, standing gazing at us from the red termite hills, and rare glimpses of beautiful lesser kudu bucks that observed us from behind screens of green brush. At lunch that day (during which an ostrich invited itself into the dining tent), I dutifully reminded the group that it was Sunday and that everyone should take his or her antimalarial (chloroquine), and carefully took my own. That afternoon, a few of us were rewarded with a sight of a huge leopard as it bounded out of an acacia shrub and brazenly walked off into tall grass.

March 14 was our last day in the field, and we spent it at Lake Jipe, on the Tanzanian border, where we saw a variety of water birds, including the rare pygmy goose. Along the way we had seen oryx, hartebeest, a huge herd of two to three hundred elephants, and even nesting secretary birds. During our seventeen days in Kenya we saw more than 60 species of mammals and 340 species of birds. At dusk that last Tuesday night, I sat on the roof of a lodge at Taita Hills and watched the waterbuck reflected in the waterhole. Far off there was a little flash of white, which I deciphered as the wind ruffling the white mane of a lesser kudu, otherwise invisible in the dark. That evening a mosquito bit me. Since I am seldom bitten by mosquitoes, I remember it clearly. As that mosquito bit, its saliva carried into my blood some tiny organisms that had been waiting in its salivary gland for this moment.

About two weeks earlier, while our group was still in London, that mosquito had bitten someone else in the Taita Hills. Although whoever was bitten probably was not suffering the acute stage of malaria, and even though that person may not have had fevers for years, swimming in his or her blood were crescent-shaped microorganisms, both male and female, of a species of protozoan (one-celled animals) called *Plasmodium falciparum.* The mosquito, a female of the genus *Anopheles,* sucked up some of those crescents along with the victim's blood. Within fifteen minutes the small male crescents had extruded long, whiplike tails and were swimming about in the mosquito's stomach in search of the larger, sedentary female forms. When the males found the females, the whips broke free from the crescents and penetrated the females, which had become rounded. Male and female together formed the equivalent of a fertilized egg.

During the next two weeks, while our group traveled from London through the northern Kenya parks, these cells became embedded in the stomach wall of the mosquito. Each cell divided to produce more and more cells in a wartlike cyst. Perhaps fifty such cysts formed in the mosquito's stomach. Then the cysts burst, and the tiny cells (perhaps 200,000 of them) made their way to the mosquito's salivary glands.

Two nights after my mosquito bite, our safari group flew from the Nairobi airport to London, where we changed planes, and by the afternoon of March 17, I was home again in New Jersey. By this time the organisms passed on to me by the mosquito had found their way to my liver; in the liver cells, they were dividing rapidly and increasing their numbers.

The next six weeks were routine. I caught up on accumulated office work and correspondence, lectured to a graduate seminar at City University, advised the Springfield, Massachusetts, museum on their proposed new African hall, gave a talk about African animals to the fourth grade at the local elementary school, finished a paper on the nomenclature of domestic animals, and worked on my notes on the spiral-horned antelopes. And I also took my children to Acadia National Park in Maine for five days.

During those six weeks, however, something else was happening. The falciparum protozoans spent about eight days in my liver; then, having increased manyfold, they all left my liver and invaded my bloodstream. There they met their first setback. Normally, they would have penetrated my red blood cells to feed on the hemoglobin within them, but also in my blood at this time was chloroquine, which I had continued to take after the trip, and it killed almost all of them. It is those few that did not succumb that have made medical history.

Those few surviving protozoans were different from the other malaria parasites in east Africa: they were resistant to chloroquine. They maintained themselves at low level in my blood, gradually reproducing, not sexually, with males and females, as they had first done in the mosquito, but by

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simple division, or splitting. In two days, each protozoan could produce from eight to thirty-two descendants, which then went out to invade more red blood cells.

Eventually, assuming that I had passed the time when any parasites could remain in my blood, I stopped taking chloroquine. Of course, the parasites that did remain, flourished. By April 30, some six weeks after the mosquito had bitten me, there were as many as 200 parasites in every drop of my blood, perhaps a billion in my whole body.

During the night of April 30 I had a chill. It was not severe, but I remember huddling deeper into my covers. When I awoke, I didn't feel well, but I didn't feel all that sick, either, and I went to the office as usual. Early that afternoon I had a headache and felt uncomfortable. I asked one of the other people in the office if there was a virus going around. I was told there was some 24-hour bug and assumed that I had it. I left for home early that afternoon and took a nap. That evening I had a temperature of 102°F. Assuming I had a virus, I started taking aspirin every four hours and drinking lots of fluids. By noon the next day I was well and had no fever. But I had some indigestion, so I stopped taking the aspirin. I awoke the next morning with a temperature of 104.5° and knew I needed medical help. A local doctor examined me, took some blood, and sent me home—back to the aspirin and fluids. He said that if I did not respond, I might have to be hospitalized.

Thursday, May 4, is a haze. I know I had fever and chills, and I was probably delirious. I was lucid long enough, however, to cancel a speech dedicating the new laboratory building at the Quincy Bog Natural Area in New Hampshire on Saturday, and to arrange for another speaker. The next day I was admitted to a local hospital, where, within ten minutes, microscopic examination of a blood smear showed that I had malaria.

Just finding malaria parasites in blood smears is not enough. There are four kinds of human malaria (there are other kinds in birds, monkeys, and rats). Two of these are relatively common; the other two are rare, although widely distributed. Probably the commonest of all is *Plasmodium vivax*, which exists in both temperate and tropical areas. It is usually called tertian or benign tertian malaria because it has a 48-hour fever cycle. (The Romans, from whom we get the word *tertian*, counted the initial day as number one, so forty-eight hours later would be the third, or tertian, day.) The other common type is *P. falciparum*. It has a 40- to 48-hour cycle and is called subtertian, malignant tertian, or aestivo-autumnal malaria. The identification of the kind of malaria is important because the human cycle differs according to the species that is present. In the falciparum malaria, for example, all of the parasites leave the human host's liver and enter the blood system where the rest of their activities take place. In the vivax type, the liver remains a reservoir of infection, although the fevers are caused by the multiplication of parasites in the blood system.

Taxonomy, the science of classification, is a major activity at the American Museum, where I have been a taxonomist for many years. I am often asked what useful purpose taxonomy serves, and now I have another example of the importance of being able to classify animals correctly, this time protozoans.

The slides of my blood were rushed to an expert malaria taxonomist, one whom the Museum retains as a specialist in tropical medicine. He identified the parasites inhabiting my red blood cells as *P. falciparum*. With my fever approaching 105°, I was started immediately on medication, which consisted of large doses of chloroquine for three days. By the end of that time, no malaria organisms could be found in my blood, and after four days in the hospital, I was discharged to recuperate at home from the damage done by the protozoans to my liver and blood.

My recovery was slow, slower than I had expected from my reading about certain explorers who, after a day or two in bed, were up and on the march right away. I was anemic from the destruction of red blood cells by the malaria parasites, my liver was enlarged, and I had other side effects, either from the malaria or the medication, including lack of stamina, indigestion, ringing in the ears, and occasional outbreaks of hives. After a week at home, I went back to working half time at the office, and at the end of May, a month after my first chill, I was working full time.

Falciparum malaria does not remain in the liver and all of the parasites are out in the blood system when the fevers occur; thus, it is very vulnerable to treatment with chloroquine. Although it is the deadliest of all kinds of malaria—Alexander, Borgia, and Cromwell are thought to have been among its victims—falciparum is now the most readily treated. The therapy for vivax malaria, on the other hand, involves not only an attack on the organisms in the blood with chloroquine but also subsequent treatment with another chemical to attack those that remain in the liver.

On June 9 I started driving south to attend the meeting of the American Society of Mammalogists in Athens, Georgia. I had some work to do along the way in Shenandoah and Great Smokies national parks. The first evening in Shenandoah National Park in Virginia, I walked to the top of a small hill to view the sunset and found it unusually hard going. I decided that my past month of inactivity had taken its toll. Two days later, in the Great Smokies, near the border between North Carolina and Tennessee, I started walking to the top of Clingman's Dome, the highest point in the park. It was a mild climb, but I couldn't make it more than halfway. Although I didn't realize it, the pressure I felt in my chest was my enlarged liver, and throughout my blood, malaria parasites were devouring the oxygen-carrying hemoglobin.

Two days later, on the morning of June 13, I was at the meeting of the board of directors of the American Society of Mammalogists, and I complained about the air conditioning being too chilly. An hour of sitting in the hot Georgia sun did not warm me, so I returned to my room and took a nap. When I woke up, I took my temperature. It was 102°. I went to the local university hospital and told the doctors I thought I had malaria again, even though I had presumably been cured. A blood smear was made, and I was examined. Since no parasites were seen in my blood, and there were no indications of malaria from the examination, the doctors suggested that I had a virus. Much relieved to have only a virus, I returned to my room and started on the prescribed aspirin and fluids. By the next day I was well and went to the meetings. But early that afternoon I felt feverish again and went back to my room. My temperature was 102°, and I started on the aspirin once more.

I was very sick the next morning, the 15th, and I called the hospital. They admitted me and within a few minutes had identified malaria parasites in my

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blood smears. The laboratory technician, who had had experience with malaria infections in Vietnam, even identified them as *P. falciparum.* The doctor attending me was not able to get in touch with the Museum's New York specialist, who was away, so she contacted the nearby Center for Disease Control in Atlanta. Once more I was given the chloroquine treatment, a somewhat higher dose this time, and again, after a few days, no parasites could be found in my blood. After five days in the hospital in Athens, I flew home. I was extremely weak from anemia but seemed to have suffered no major liver or kidney damage.

The Museum's tropical disease expert was still away, so I visited another specialist. He examined the microscope slides of the parasites that I had brought back and confirmed the identification of *P. falciparum.* The Center for Disease Control also confirmed that this was what I had had both times—except that falciparum malaria is not supposed to recur after treatment, at least not if it has been picked up in east Africa. (Chloroquine-resistant malaria was, however, known from Southeast Asia, and other areas.) There was a suspicion that I may have had a mixed infection of vivax and falciparum malaria, but the specialists had to agree that there was no sign of vivax in any of my blood smears. They began to think that I had not told the truth about taking the medication. During World War II, GI's in the Pacific, unhappy at turning yellow from the atabrine medication then in use, became adept at feigning swallowing the pills and later discarding them. Although chloroquine has no such effects and I knew that I had taken the medication, the doctors also knew that I shouldn't have had falciparum malaria again. They put me on a five-week course of chloroquine once more, trusting me to take the pills and also requiring me to have my blood tested every week.

Again my recuperation was slow. By mid-July, however, I decided that I was well enough to start a mild exercise program, and within a few days was walking a brisk mile in less than fourteen minutes. But I had to stop this regimen when the constraining pressure I had felt before in my chest returned. On July 27 I finished my five weeks of medication, and in August I returned to the office.

There was a lot of accumulated mail, as well as a big pile of scientific journals. Going through *Science,* a weekly published by the American Association for the Advancement of Science, I saw an article by two researchers at Rockefeller University in New York. They had been culturing falciparum malaria parasites in their laboratory, and by adding dilute chloroquine solution to the medium, had found out how rapidly the parasites could develop resistance to chloroquine. Although the amounts of chloroquine they used were minuscule compared with the quantities that had been in my blood, in as little as five weeks, the protozoans were able to withstand three times the dose of chloroquine that had killed them at first.

I wrote to the Rockefeller parasitologists and told them of my case. Even though my doctors did not really believe that I had had resistant malaria from east Africa, indefinable little twinges here and there led me to believe I still had malaria. I told the Rockefeller scientists that, if I did have malaria, my parasites might be of extreme interest to them since they would probably be far more resistant to chloroquine than any that they had cultured in their lab. The Rockefeller scientists wrote that they were interested, but I could also read in their letter their doubts that I had really had a recurrence of falciparum malaria. They suspected that I had had the vivax type. That would explain my relapse since I had not had the therapy that would eliminate the vivax parasites in the liver. Nevertheless, they told me that they would want a blood sample, and how it should be taken, if I had another attack.

On August 22 I awoke as usual at 5:30 but felt a little under the weather. Call it a premonition, but I decided to take a thermometer to the office with me. Together with my son, Russell, who was working as a volunteer in the Museum's photographic archives, I left the house at 6:30, chatting along the way with my usual CB associates, Cookie Monster, Grease Monkey, Caveman, and Humpty Dumpty. About 9:00 I had what I now know is a typical malarial headache and took my temperature—it was 99.4°, not abnormal. Nevertheless, I *knew* I had malaria again and called Russ, who decided to go home with me. By the time we were back in New Jersey, my temperature was down to 98.8°, but I still knew I was having another attack of malaria. I arranged to have a blood smear made at a local hospital, and by early afternoon, they admitted me as a patient, having once more found the parasites in my blood.

We telephoned the New York specialist who had treated me after the second attack, and he had me transferred to a New York City hospital. When I arrived early that evening, I was met by one of the Rockefeller doctors, whom I had called immediately from New Jersey, and I handed him a large plastic container with ice and a sample of my blood that I had had drawn for him as soon as the malaria had been confirmed. By that night, when they finally started giving me medication—large doses of chloroquine again—my temperature was up to 103°.

I was now beginning to make believers out of the experts, but it was hard. The cultures that the Rockefeller researchers had started "took" and began growing and dividing. After two days even they had to admit that I didn't have vivax. They had also excluded one of the rare types. That left falciparum or the other rare type. By the next day they were convinced that I did indeed have falciparum malaria and that I seemed to have one of the first cases of this form from east Africa that was resistant to chloroquine.

Shortly before my trip, a Dane had contracted a case of drug-resistant malaria on a tour in Africa, and later that year a Georgia man, who had been on a safari in Tanzania, came down with malaria that proved resistant to chloroquine. There had been reports of possible drug-resistant malaria cases from east Africa before this, but without solid documentation. The *Morbidity and Mortality Weekly Report* of the Center for Disease Control in Atlanta for November 24, 1978, reported on all three of these cases, saying they "present the strongest evidence to date that chloroquine-resistant *P. falciparum* malaria has appeared in Africa."

While the chloroquine was again knocking down the parasites in my blood those first three days in the New York hospital, samples of my blood were flown to the Center for Disease Control. There they began culturing the parasites and also inoculated a South African owl monkey with some of my blood in hopes of establishing the parasites in that poor creature. My previous records of malaria were extracted (despite an early computer output that showed no record of my

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case) and the first two attacks were reconfirmed as falciparum.

After a day or two without fever, I began to feel pretty well and had little of the discomfort and weakness that followed the first two attacks. My main problems were a shortage of puncturable veins for the technicians' frequent samples and some soreness around the ribs from their constant probing to find out if my spleen was enlarged (it wasn't, although this is often a characteristic of malaria) and how big my liver was (it was enlarged). I was looking forward to an early return home and was greatly disappointed to find that they were going to keep me in the hospital for a considerable time.

The main experience with chloroquine-resistant malaria has been with strains from Southeast Asia. At the beginning of the Vietnam war about 5 percent of the falciparum malaria in Southeast Asia was resistant. By the time we left, the malaria in that region was more than 95 percent resistant. New medicines to overcome this resistance were developed, but most were so destructive to the patient that they were almost worse than the malaria itself. Ultimately, however, a reasonable Southeast Asian "cure" was developed from a new combination of drugs. And so, two days after I had finished the chloroquine treatment, I was put back on medication, a powerful modification of the Southeast Asian treatment. This continued for five days, and finally, twelve days after I had been admitted, I was allowed to go home to recuperate. It was the beginning of September, almost six months since the Kenya trip, when I was discharged from the hospital.

One of the first things that I had asked when it was finally confirmed that I had resistant falciparum malaria was whether anyone else on our tour could have gotten it and not yet have experienced an attack. I was assured by all of the experts that if the other tour members had not come down with it by August, there was no likelihood that they would. I assumed that I would have heard if anyone else on the tour had been sick with malaria, and I had not.

We tend to think of malaria as a tropical disease, but it is not. At one time it ranged throughout most of eastern North America as far north as Quebec, and it has been known to occur as far north as the sixtieth parallel in Russia. The digging of the Erie Ca-

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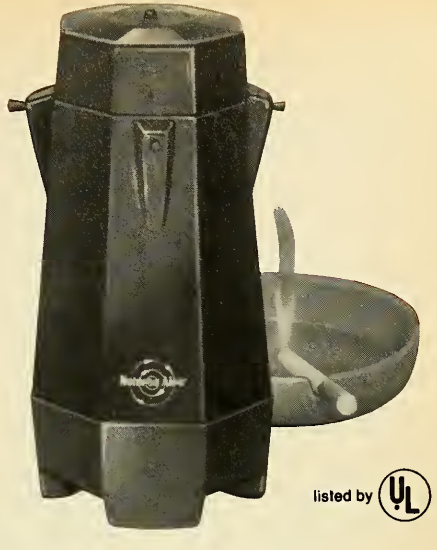

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nal was almost not completed because of the presence of malaria in the Montezuma Marshes (now a wildlife refuge) in upstate New York. In 1935 there were more than 4,400 deaths from malaria in the United States. By 1946 the total had been reduced to 341. At present all of the malaria in the United States comes from outside the country. In 1977 there were 480 cases of malaria reported (as required by law) to the Center for Disease Control. About one-third were acquired in Africa, and more than half were caused by *P. falciparum,* and of these, two cases ended in death. Of twenty people on a 1977 Kenya tour similar to ours, three did not take chloroquine as a preventive. Each of the three came down with falciparum malaria and one died within three days, never having sought treatment.

Malaria is considered to have been one of mankind's greatest killers. Association with night air was made early, and the name *malaria* itself refers to "bad air." Another association was made with swampy regions. Although swamps are breeding places for mosquitoes, the damp night air, not the insects, was generally thought to convey the disease.

All who have been to Africa remember the tall, yellow-barked acacia trees that grow along streamsides. The early explorers called these acacias "fever-trees," a name we still use. In the past, overnight camping near these acacias was sure to result in illness.

A French Army physician in Algeria, Charles Louis Alphonse Laveran, discovered the malaria organism in 1880, just a century ago, but it was not until 1898 that Ronald Ross proved that the malaria parasites were dependent upon certain mosquitoes for their transmission. Both Laveran and Ross won Nobel Prizes—Ross in 1902 and Laveran in 1907. Since Ross, the war against malaria has largely involved two aspects—control of mosquitoes and chemotherapy against the disease in humans. The greatest success in the war against malaria came in the years after the Second World War, when the combined availability of DDT for mosquito control and chloroquine for prevention and therapy served to reduce the disease to its lowest level in history. Indeed, public health officials hoped that they would soon see malaria totally eliminated from the earth and projected 1960 as the year in which malaria infections would be reduced by 90 percent worldwide.

Alas, that hope is now gone. Not only has there been an increase in the resistance of the protozoans to chloroquine, as I know all too well, but mosquitoes have become more resistant to DDT. The economics of the current energy crisis has also affected malaria-control programs, with some of the poor nations giving up altogether for lack of funds. And a very human problem has occurred in many regions where, despite the funds provided, the money seems to have disappeared into the pockets of officials without any control activity taking place.

Evidence of the losing battle appears in the figures of nearly 500 cases in the United States in 1977, and 1,500 cases in England, which has much greater traffic from malaria zones. In the decade prior to 1973, the annual number of civilian cases of malaria in the United States was a fairly constant 100 to 200, but it rose to 302 in 1973 and to 480 in 1977. Specialists, noting a growing incidence in places where the disease had been at low levels not too long ago, estimate more than 150 million cases of malaria will occur this year, with a million deaths in Africa alone.

The fight against malaria continues, however. The emphasis has shifted to attempts to find a vaccine that will prevent humans from coming down with the disease. The development in recent years of a means of culturing falciparum malaria in vitro and the ability to infect owl monkeys with the parasites have aided progress toward a vaccine. But problems remain. For one thing, the protozoans go through varied phases in the human body, and each form can cause different immune reactions by the host and respond differently to experimental vaccines. Another major problem is that, unlike the response of the body to bacterial and virus infections, immunological response to parasites is slow, and to introduce the vaccine to the immune system it is necessary to use a stimulant, called an adjuvant. Under experimental conditions, monkeys injected with vaccine and adjuvant are known to have survived malaria infections sufficiently to indicate that they received marked protection from the injections —but they suffered terrible side effects from the adjuvant, making it unacceptable for human use. A search is on to modify or eliminate the adjuvant as a route to a successful vaccine, and laboratories in several parts of the world are hard at work on this problem. For the investigators, a Nobel Prize may be the reward. For the rest of us, the savings of millions of lives from the worst of human parasites is the stake.

What is the cost of malaria? For me, it meant ninety-two days out of work, twenty of which I spent in hospitals. Thanks to a vast accumulation of sick leave, I was paid my salary for work I didn't do, and my health insurance paid thousands of dollars for hospital and doctors' bills, incidental lab fees, and medication. In addition, there were expenses to my family that would not have been incurred had I been healthy. I also lost income from consultation, writing, and lecturing fees. All in all, the minimum direct cost of my case was in excess of $27,000. The indirect losses may be even greater because, among other things, a year of recuperation has delayed my return to Africa to continue my studies of antelopes in Botswana, and I have lost contact with my identifiable animals. While neither salaries nor hospital expenses are so high in the third world countries where malaria is most prevalent, one can readily imagine the drain that the 150 million annual cases have on the economies of those nations.

It was certainly no fun to have malaria or to see myself written up in the Center for Disease Control's *Morbidity and Mortality Weekly Report* or in the *Journal of the American Medical Association* as "a 49-year old zoologist. . . ." It was frightening to roll around with the "sweats," have a 104.5° fever, and experience what I can only call premature senility during my ever-so-slow recuperation. And, although I have been free of malaria symptoms since September, and trust that I am cured, I have to stay healthy until next September to convince the doctors. On the other hand, there has been some intellectual challenge and I have broadened my knowledge of another zoological area. And, in the test tubes at Rockefeller University and in some monkeys at the Center for Disease Control, "my" falciparum may be growing and dividing and may someday lead to the development of a safe vaccine for this scourge, and perhaps a Nobel Prize for the investigators. That's as close as I'll ever get to it.

*Richard Van Gelder, curator of mammals at the American Museum of Natural History, is a frequent traveler to Africa. He had never contracted malaria before.*

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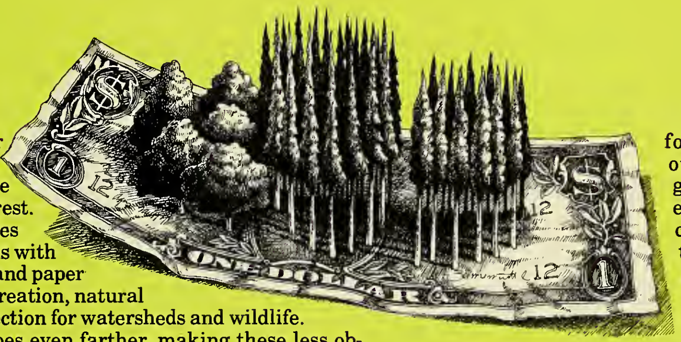

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So far, the commercial forest has been able to cope with all the demands made on it. But we can't expect it to continue to provide its benefits automatically.

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# The First Forebear

*Did we multicellular creatures evolve by division or amalgamation?*

**by Stephen Jay Gould**

I spent the last day of our late and largely unlamented decade reading through a stack of New York Sunday papers for the last weekend of the 1970s. Prominently featured, as always in the doldrums of such artificial transition, were lists of predictions about "ins" and "outs": What will the eighties reject that the seventies treasured? What, despised during the seventies, will the eighties rediscover?

This surfeit of contemporary speculation drove my mind back to the biological ins and outs of the last transition between centuries. The hottest subject of biology in the last century did suffer a pronounced eclipse in our times. Yet I happen to maintain a strong fondness for it. I also believe that new methods will revive it as a major concern for the remaining decades of our century.

Darwin's revolution led a generation of nineteenth-century natural historians to view the reconstruction of life's tree as their most important evolutionary task. They did not focus narrowly upon little twiglets (the relation of lions to tigers) or even upon ordinary branches (the link between cockles and mussels). They sought to root the trunk itself and to identify its major limbs: How are plants and animals related? From what source did the vertebrates spring?

In their mistaken view, these naturalists also possessed a method that could extract the answers they sought from the spotty data at their disposal. For, under Haeckel's "biogenetic law"—ontogeny recapitulates phylogeny—an animal climbs its own family tree during the development of its embryo. The simple observation of embryos should reveal a parade of adult ancestors in proper order. (Nothing is ever quite so uncomplicated, of course. The recapitulationists knew that some embryonic stages represented immediate adaptations, not ancestral reminiscences; they also understood that stages could be mixed up, even inverted, by unequal rates of development among different organs. Yet they believed that such "superficial" modifications could always be recognized and subtracted, leaving the ancestral parade intact.) E.G. Conklin, who later became an opponent of "phylogenizing," recalled the beguiling appeal of Haeckel's law:

> Here was a method which promised to reveal more important secrets of the past than would the unearthing of all the buried monuments of antiquity—in fact nothing less than a complete genealogical tree of all the diversified forms of life which inhabit the earth.

But the turn of the century heralded the collapse of recapitulation. It died primarily because Mendelian genetics (rediscovered in 1900) rendered its premises untenable. (The "parade of adults" required that evolution proceed only by an addition of new stages to the end of ancestral ontogenies. But if new features are controlled by genes, and these genes must be present from the very moment of conception, then why shouldn't new features be expressed at any stage of embryonic development or later growth?) The assumption that ancestral reminiscences could always be distinguished from recent embryonic adaptations had not been sustained. Too many stages were missing, too many others discombobulated. The application of Haeckel's law produced endless, unresolvable, fruitless argument, not an unambiguous tree of life. Some tree builders wanted to derive vertebrates from echinoderms, others from annelid worms, still others from horseshoe crabs. E.B. Wilson, apostle of the "exact," experimental method that would supplant speculative phylogenizing, complained in 1894:

> It is a ground of reproach to morphologists that their science should be burdened with such a mass of phylogenetic speculations and hypotheses, many of them mutually exclusive, in the absence of any well-defined standard of value by which to estimate their relative probability. The truth is that the search . . . has too often led to a wild speculation unworthy of the name of science; and it would be small wonder if the modern student, especially after a training in the methods of more exact sciences, should regard the whole phylogenetic aspect of morphology as a kind of speculative pedantry unworthy of serious attention.

Phylogenizing fell from general favor, but you can't keep an intrinsically exciting subject down. (I speak of high-level phylogenizing—the trunk and limbs. For twigs and small branches, where evidence is more adequate, work has always proceeded apace, with more assurance and less excitement.) We didn't need "Roots" to remind us that genealogy exerts a strange fascination over people. If uncovering the traces of a distant great-grandparent in a small overseas village fills us with satisfaction, then probing further back to an African ape, a reptile, a fish, that still-unknown ancestor of vertebrates, a single-celled forebear, and even to the origin of life itself can be awesome. Unfortunately, the further back we go the more fascinated we become and the less we know. In this column, I will discuss one classic issue in phylogenizing. It is an example of the joys and frustrations of a subject that will not go away: the origin of multicellularity in animals.

Ideally, we might hold out for a simple, empirical resolution of the issue. A sequence of fossils perfectly intermedi-

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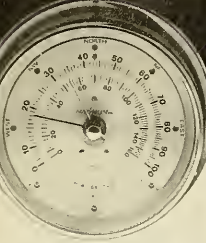

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ate between a protist (single-celled ancestor) and a metazoan (multicelled descendant) would erase all doubt. But the transition occurred in unfossilizable, soft-bodied creatures long before the inception of an adequate fossil record. The first metazoan fossils from some 600 million years ago do not surpass the most primitive modern metazoans in their similarity to protists. We must turn to living organisms, hoping that some multicelled descendants still have appropriate marks of ancestry.

Genealogical reconstructions are based on the similarities between postulated relatives. "Similarity," unfortunately, is not a simple concept. It arises for two fundamentally different reasons. The construction of evolutionary trees requires that the two be rigorously separated, for one indicates genealogy while the other simply misleads us. Two organisms may maintain the same feature because both inherited it from a common ancestor. These are *homologous* similarities, and they indicate "propinquity of descent," to use Darwin's words. Forelimbs of people, porpoises, bats, and horses provide the classic example of homology in most textbooks. They look different, and do different things, but are built of the same bones. No engineer, starting from scratch each time, would have built such disparate structures from the same parts. Therefore, the parts existed before the particular set of structures now housing them: they were, in short, inherited from a common ancestor.

Two organisms may also share a feature in common as a result of separate but similar evolutionary change in independent lineages. These are *analogous* similarities; they are the bugbear of genealogists because they confound our naïve expectation that things looking alike should be closely related. The wings of birds, bats, and butterflies adorn most texts as a standard example of analogy. No common ancestor of any pair had wings.

Our difficulties in identifying the trunks and limbs of life's tree do not record muddled thinking about methods. All eminent naturalists, from Haeckel on (and even before) stated their procedure correctly: separate homologous from analogous similarity, discard analogies, and build genealogy from homology alone. Haeckel's law was a procedure, unfortunately wrong, for the recognition of homology. The goal is, and has been, clear enough.

In a broad sense, we know how to identify homology. Analogy has its limits. It may build striking external, functional similarity in two unrelated lineages; but it does not modify thousands of complex and independent parts in the same way. At a certain level of precision, similarities must be homologous. Unfortunately, we rarely have enough information to be confident that this required level has been attained. When we compare primitive metazoans with different protists as potential relatives, we often work with only a few features held in common for any contrast—too few to be sure about homology. Moreover, small genetic changes often have profound effects upon external, adult form. Therefore, a similarity that looks too uncanny and complex to arise more than once may actually record a simple and repeatable change. Most importantly, we aren't even comparing the right organisms, but only pale reflections of them. The transition from protist to metazoan occurred more than 600 million years ago. All true ancestors and original descendants disappeared eons ago. We can only hope that their essential, identifying features have been retained in some modern forms. Yet, if retained, they have surely been modified and overlain with a plethora of specialized adaptations. How can we separate original structure from later modification from new adaptation? No one has ever found an unfailing guide.

Only two scenarios have been favored for the origin of metazoans from protists: in the first (amalgamation), a group of protistan cells came together, began to live as a colony, evolved a division of labor and function among cells and regions, and finally formed an integrated structure; in the second (division), cellular partitions formed within a single protistan cell. (A third potential scenario, repeated failure of daughter cells to separate following cell division, has few takers these days.)

We immediately come up against the problem of homology. Did multicellularity arise only once? Or several times? When we decide how it arose once in the most primitive animal, have we explained its occurrence in all animals? In other words, is the multicellularity of various animal lineages homologous or analogous?

The metazoan group usually regarded as most primitive, the sponges, arose by the first scenario, amalgamation. Modern sponges are little more

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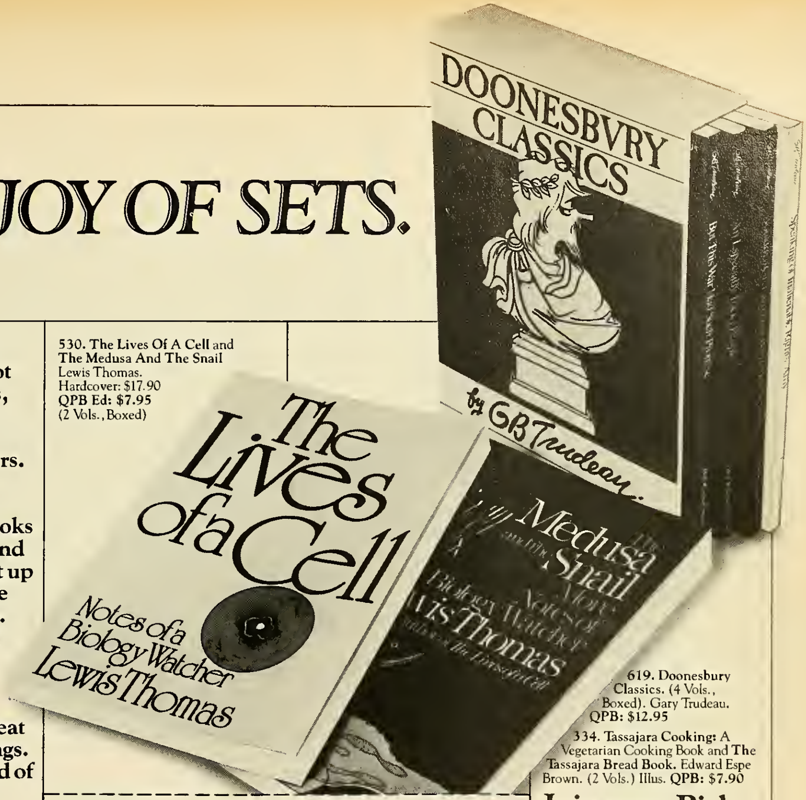

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than loosely knit federations of flagellated protists. In some species, cells can even be disaggregated by passing the sponge through a fine silk cloth. The cells then move independently, reaggregate into small clumps, differentiate, and regenerate an entire new sponge in its original form. If all animals arose from sponges, then multicellularity is homologous throughout our kingdom, and it arose by amalgamation.

But most biologists regard sponges as an evolutionary dead end without subsequent descendants. Multicellularity is, after all, a prime candidate for frequent, independent evolution. It displays primary features of analogous similarity: it is reasonably simple to accomplish, it is highly adaptive, and it is the only potential path to the benefits it confers. Ostrich eggs notwithstanding, single cells cannot become very large. The earth's physical environment contains scores of habitats available only to creatures beyond the size limit of a single cell. (Consider only the stability that arises from being large enough to enter a realm where gravity overshadows the forces that act upon surfaces. Since the ratio between surface and volume declines with growth, increasing size is the surest path to this realm.)

Actually, multicellularity evolved separately in the three great higher kingdoms of life (plants, animals, and fungi), and it probably arose several times in each kingdom. Most biologists agree that all origins within plants and fungi occurred by the amalgamation of protistan colonies. Sponges also arose by amalgamation. May we then close the issue and state that multicellularity, although analogous both across and within kingdoms, evolved in the same basic way each time. Modern protists include colonial forms that display both regular arrangement of cells and incipient differentiation. Remember the *Volvox* colonies of high school biology labs? (I must confess that I don't. I attended a public high school in New York just before *Sputnik* went up. We had no lab at all, although it arrived in a flash just as I left.) Some volvoxes form colonies with a definite number of cells arranged in a regular manner. The cells may differ in size, and reproductive function may be confined to cells at one end. Is it such a big step to a sponge?

Only among animals may we make a good case for another scenario. Did some animals, ourselves included, arise by division? This question cannot be answered until we resolve one of the oldest riddles in zoology: the status of the phylum Cnidaria (corals and their allies, but also including the beautiful, transluscent Ctenophora, or comb-jellies). Almost everyone agrees that the Cnidaria arose by amalgamation. The dilemma resides in their relationship with other animal phyla. Almost all possible schemes have their supporters: cnidarians as descendants of sponges and ancestors of nothing else; cnidarians as a separate branch of the animal kingdom without descendants; cnidarians as the ancestors of all "higher" animal phyla (the classical view of the nineteenth century); cnidarians as degenerate descendants of a higher phylum. If either of the last two schemes can ever be established, then our issue is settled—all animals arose by amalgamation, probably twice (sponges and everything else). But if the "higher" animal phyla are not closely related to cnidarians, if they represent a third, separate evolution of multicellularity in the animal kingdom, then the scenario of division must be seriously considered.

Supporters of a separate origin for the higher animals generally cite the platyhelminths (flatworms) as a potentially ancestral stock. Earl Hanson, a biologist at Wesleyan University, has been a leading crusader, both for a platyhelminth origin of higher animals and for the scenario of division. If his iconoclastic view prevails, then the higher animals, including humans of course, are probably the only multicellular products of division, rather than amalgamation.

Hanson has pursued his case by studying the similarities between a group of protists known as ciliates (including the familiar *Paramecium*) and the "simplest" of flatworms, the Acoela (named for their failure to develop a body cavity). Many ciliates maintain large numbers of nuclei within their single cell. If cellular partitions arose between the nuclei, would the resulting creature be enough like an acoelous flatworm to justify a claim for homology?

Hanson documents an extensive set of similarities between the multinucleate ciliates and the multicellular acoeles. Acoeles are tiny marine flatworms. Some can swim, and a few live in water up to 800 feet in depth. But most crawl along the sea bottom in shallow water, living under rocks or in sand and mud. They are similar in size to the multinucleate ciliates. The internal similarities of ciliates and acoeles reside primarily in their shared simplicity, for acoeles, unlike conventional metazoans, lack both a body cavity and the organs associated with it. They have no permanent digestive, excretory, or respiratory system. Like the ciliate protists, they form temporary food vacuoles and perform digestion within them. Both ciliates and acoeles divide their bodies roughly into inner and outer layers. Ciliates concentrate their nuclei in the inner layer. Acoeles devote an inner region to digestion and reproduction and an outer region to locomotion, protection, and the capture of food.

The two groups also display some outstanding differences. Acoeles build a nerve net and reproductive organs that can become quite complex. Some have penises, for example, and impregnate each other hypodermically through the body wall. They undergo embryonic development after fertilization. Ciliates, by contrast, have no organized nervous system. They divide by fission and have no embryology, although they do indulge in sex via a process called conjugation. (In conjugation, two ciliates come together and exchange genetic material. They then separate and each divides later to form two daughters. Sex and reproduction, combined in nearly all metazoans, are separate processes in ciliates.) Most prominently, of course, acoeles are cellularized; ciliates are not.

These differences should not debar a hypothesis of genealogical relationship. After all, as I argued previously, contemporary ciliates and acoeles are more than half a billion years beyond their potential common ancestor. Neither represents a transitional form in the origin of multicellularity. The debate centers instead on the similarities and on the oldest and most basic issue of all: are the similarities homologous or analogous?

Hanson argues for homology, claiming that the simplicity of acoeles is an ancestral condition within the flatworms. His detractors reply that the simplicity of acoeles is a secondary result of their "regressive" evolution from more complex platyhelminths, which have intestines and excretory organs.

Unfortunately, the similarities that Hanson cites are of the sort that always produce unresolvable wrangling about homology versus analogy. Many are based upon the *absence* of com-

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plexity in acoeles, and evolutionary loss is easy and repeatable.

Moreover, the simplicity of acoeles is a predictable result of their small body size. Many physiological functions, including breathing, digestion, and excretion, must proceed through surfaces and serve the entire body's volume. Large animals have such a low ratio of external surface to internal volume that they must evolve internal organs to provide more surface. (Functionally, lungs are little more than bags of surface for exchange of gases, while intestines are sheets of surface for the passage of digested food.) But small animals maintain such a high ratio of external surface to internal volume that they often can breathe, feed, and excrete through the external surface alone. The smallest representatives of many phyla also lose internal organs. *Caecum*, for example, the smallest snail, has lost its internal respiratory system entirely and takes in oxygen through its external surface.

Other similarities, cited by Hanson, may be homologous, but these are so widespread among other creatures that they merely illustrate the broader affinity of all protists with all metazoans, not any specific pathway of descent.

Hanson is well aware that he cannot prove his intriguing hypothesis with the classical evidence of morphology and function. "The best we can say," he concludes, "is that many suggestive similarities are present [between ciliates and acoeles], but no rigorously definable homologies."

Is there another method that might resolve the issue or are we permanently condemned to unresolvable wrangling? Fortunately, we now have a potential source of such information—the DNA sequence of comparable proteins. All protists and metazoans share many homologous proteins. Each protein is built of a long chain of amino acids; each amino acid is coded by a sequence of three nucleotides in DNA. Thus, the DNA code for each protein may contain hundreds or thousands of nucleotides in a definite order.

Evolution proceeds by substitution of nucleotides. After two groups split from a common ancestor, their nucleotide sequences begin to accumulate changes. The number of changes seems to be at least roughly proportional to the amount of time since the split. Thus, overall similarity in nucleotide sequence for homologous proteins may measure the extent of genealogical separation. A nucleotide sequence is a homologizer's dream.

Techniques are just now becoming available for the routine sequencing of nucleotides. I believe within ten years we will be able to take homologous proteins from all the ciliate and metazoan groups at issue, sequence them, measure the similarities between each pair of organisms, and obtain greater insight (perhaps even resolution) for this old genealogical mystery. If acoeles are most similar to protist groups that might achieve multicellularity by evolving cell membranes within their bodies, then Hanson will be vindicated. But if they are closest to protists that can reach multicellularity by integration within a colony, then the classical view will prevail, and all metazoans will emerge as the products of amalgamation.

The study of genealogy has been unfairly eclipsed in our century by the analysis of adaptation, but it cannot lose its power to fascinate. Simply consider what Hanson's scenario implies about our relationship with other multicellular organisms. Few zoologists doubt that all higher animals achieved their multicellular status by whatever method the flatworms followed. If acoeles evolved by the cellularization of a ciliate, then our multicellular body is the homolog of a single protistan cell. If sponges, cnidarians, plants, and fungi arose by amalgamation, then their bodies are the homologs of a protistan colony. Since each ciliate cell is the homolog of an individual cell in any protistan colony, we must conclude—and I do mean this literally—that the entire human body is the homolog of a single cell in a sponge, coral, or plant.

The curious paths of homology go further back. The protistan cell itself may have evolved from a symbiosis of several simpler prokaryotic (bacterial or blue-green algal) cells. Mitochondria and chloroplasts seem to be the homologs of entire prokaryotic cells. Thus, each cell of any protist, and each cell in any metazoan body, may be, by genealogy, an integrated colony of prokaryotes. Shall we then view ourselves both as a congeries of bacterial colonies and as the homolog of a single cell in a sponge or onion skin? Think upon it next time you swallow a carrot or slice a mushroom.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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# The Alien Strategy

*Not all parasites trust to luck*

**by Milton Love**

I was perhaps ten years old when I saw *Invasion of the Body Snatchers.* Sitting in the darkened theater, greedily ingesting copious quantities of taffy and caramels, I watched spellbound as aliens from outer space took control of human bodies. Young sophisticate that I was, the film's impression on me was sufficiently profound that I spent most of that year sleeping with a night light.

Art being but a poor reflection of nature, it is not surprising that some organisms practice their own form of "body snatching"—entering a host and shaping host behavior to their own needs.

The lot of most parasites is not a happy one. The chances are remote that any single individual will survive to reproduce because in many species, the parasite must pass through one, two, or three intermediate hosts before landing in the "definitive" host, the one in which it attains mature form. And many parasite larvae are passive guests, trusting to chance that they will be passed from host to host.

To overcome these long odds, many species follow Gen. Nathan Bedford Forrest's advice on how to win battles: "Git thar fustest with the mostest" (there is evidence that he phrased this somewhat more grammatically). A female human roundworm, *Ascaris lumbricoides*, for instance, may produce as many as 200,000 eggs per day, flooding the environment with progeny.

Some parasites have opted for a different strategy: they alter the normal behavior of their hosts so as to increase their chances of transmission to other organisms. An example is the sheep liver trematode, *Dicrocoelium dendriticum.* Although a sheep is the definitive host, intermediate ones through which the worm must pass are a snail and an ant. Since ants do not form the bulk of a sheep's diet, the problem would be to increase the opportunity for sheep to accidentally swallow infected ant hosts. We might expect there to be any number of frustrated sheep liver trematodes frittering away their golden years inside ants.

In fact, the worm overcomes this dilemma by burrowing into the ant's brain and forcing it to behave so as to optimize the chances of its being ingested by a sheep. Normal behavior for an uninfected ant is to be active on the soil surface during the cool mornings and afternoons, retreating to burrows during midday, when higher temperatures might be detrimental. A parasitized ant, however, climbs up to the top of a grass blade during morning hours, clamps its jaws into the blade, and becomes immobile. As midday temperatures rise, the ant retreats down the blade, only to return in the cooler afternoon.

This is an elegant relationship indeed. The ant's (and the parasite's) chances of being eaten by sheep are increased, but the host's midday retreat is still allowed, insuring that the host will survive the higher temperatures and repeat the behavior if necessary.

Other parasites make their hosts more available to their usual predators. *Brachylecithum mosquensis*, a trematode found in robin livers, breaks down the antipredator mechanisms of its intermediate host, the carpenter ant. Although normally small, reclusive, photophobic animals, when infected, carpenter ants are quite obese and remain out and visible—slowly circling or remaining immobile for one or two hours. Infected hosts are also more active during cooler hours when the birds feed.

In these two cases, the parasites invade the brains of their hosts, but this is not always necessary to alter behavior. The tapeworm *Ligula intestinalis* infects the body cavity of its intermediate host, small fish such as sticklebacks, and the gut of its definitive host, fish-eating birds. The worm larva fills up much of the fish's body cavity, and the belly distends markedly, apparently causing great stress. Infected fish are more sluggish, less apt to join schools, and more likely to swim near the surface. This behavior and their increased size make infected fish more visible and available to fish-eating birds.

In at least one relationship, a parasite behaves so that only part of its host is eaten. Snails are the intermediate hosts of *Leucochloridium macrostomum*, a trematode utilizing songbirds as its definitive host. After entering the snail and undergoing a number of morphological changes, the worm larvae migrate to the snail's tentacles. Once in place, the larvae swell enormously, becoming bright green with yellow brown rings. As the infected tentacles expand and become transparent, they reveal the multihued parasite within. At this point, the normally shadow-dwelling snails become attracted by light and the parasite begins to pulse at forty to seventy beats per minute, causing the tentacles to vibrate. Attracted to what appear to be brightly colored, swaying insects, the songbirds pluck off the snail's tentacles, complete with the undoubtedly smug parasite.

Transmission of parasites does not always depend on hosts being eaten. Here too, some parasites increase their chances of survival.

*Sphaerularia bombi* is a nematode that infects queen bumblebees. In late summer and fall the queens burrow into soil banks and hibernate. There they are infected with adult female nematodes. Once inside the queens, the females produce larvae, which eventually take control of the bees. Instead of making burrows when the next hibernation season arrives, infected bees fly about continually and dig small soil depressions into which they deposit nematode larvae. The infected queens die soon afterward,

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while the larval worms mature, males and females mate, and the fertilized female worms lie in readiness for unparasitized queen bees.

Shaping host behavior is not the only mechanism by which a parasite may increase its survival or reproductive potential.

Intriguing examples include the so-called parasitic castrators, organisms that sterilize their hosts, either directly (the parasite living within the gonads and destroying reproductive tissue) or indirectly (producing or stimulating the host to produce substances that lead to sterilization). Many parasites, including dinoflagellates, ciliates, trematodes, tapeworms, and copepods, have been implicated in this strategy.

The barnacle *Sacculina* is a dramatic case in point. Emitted into the water as a planktonic larva, the barnacle attaches itself to a crab. The barnacle larva degenerates into a mass of relatively undifferentiated tissue and flows through a dartlike tube thrust into the host. These cells are carried by the host circulatory system to the gut, where they multiply, forming an intricately branching network that soon spreads throughout the body. The denouement is that the host may not mature sexually, reproduce, or molt.

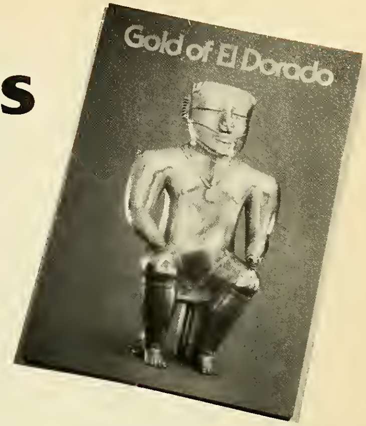
The benefits of host castration to the parasite are not always apparent and, indeed, in many cases may not exist. In several instances, however, it is possible to postulate advantages accruing to the parasite. There is some evidence that castrated hosts live longer and grow larger, perhaps because energy that might normally go toward reproduction can be utilized for tissue building, antibody production, and so on. For the parasite this could mean a longer reproductive life (because the host lives longer) and greater fecundity (often directly correlated with host size).

It would be dramatic to end this discussion by reporting that parasites (in the manner of *Brachylecithum*) influence human behavior—that, for instance, the larval stage of a bear parasite can cause humans to spread themselves with honey and hurl their bodies in front of astonished (and delighted) bruins. But there are no such parasites.

Now, if I were just sure of that, I could turn off my night light.

*Milton Love is a research associate in the Department of Biology at Occidental College, Los Angeles.*

# An Art Book That Took Centuries To Create



It took the American Museum of Natural History four years to arrange its exceptional exhibition of more than 500 pieces of ancient gold from Colombia. But those few years are a brief time when compared with the decades archeologists have spent digging (literally!) and studying the gold artifacts from tombs, caves, and buried sites. And all that time is short when compared with the many centuries prehistoric Indians practiced their craftsmanship and artistry to create these treasures.

So when it became the United States sponsor for this outstanding collection, the American Museum faced a dilemma. Could we do justice to all this effort and scholarship and beauty? We think we have. First, by dramatically displaying *Gold of El Dorado: The Heritage of Colombia* in one of our largest halls. The glowing reports from visitors tell us our efforts have been worthwhile. If you don't have a chance to see the show for yourself in New York, we hope you will see it in Chicago, San Francisco, or New Orleans on its year and a half tour.

The second challenge for the American Museum was the creation of an appropriate book to accompany the exhibition. We decided against a traditional catalog; against a small, boring volume with tiny black-and-white pictures that could never do justice to these fine objects. Instead, we decided to present a select number of the finest pieces of pre-Columbian gold in a large, stunning format. And to represent the three important elements that make a great art book we chose outstanding professionals.

First, photographer Lee Boltin. One of the greatest photographers of art objects, he also took the famous pictures of the Tutankhamun show. We sent him abroad to find and record great pieces of pre-Columbian art.

Second, archeologist Warwick Bray, from the University of London. One of the world's foremost authorities on pre-Columbian art, Bray is also a skilled writer, able to present fascinating background in a succinct, readable essay in the book. Dr. Bray organized the Colombian gold exhibition in London.

Third, Harry N. Abrams, Inc., America's leading publisher of fine art books. In a co-publishing venture with the American Museum, Abrams designed the book, supervised the preparation of 30 large color plates, and monitored the fine-quality printing.

The result is an unprecedented exhibition book. It is bold and big—each plate is 16 by 11½ inches—bigger than this magazine *opened up*. The paper is heavier than most posters. In fact, many persons have purchased two copies of the book in order to have one set of these fine art prints for framing.

And now for the happy ending. Because the Museum is a co-publisher, we are able to offer this soft-bound art book at a major savings from its normal retail price of $12.50. We are pleased to offer *Gold of El Dorado* to subscribers for only $8.95—a 28% savings off its regular price. This special offer is valid only during the exhibition and only while our limited supply lasts. We suggest that you order one or more copies immediately. Of course, if you are not satisfied after you have had an opportunity to examine it in your home, simply return the book and the Museum will refund the purchase price.

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# Horse and Buggy Island

*This renowned Michigan resort fought its dung-breeding flies with pesticides until a new insect plague emerged*

**by M. Keith Kennedy and Richard W. Merritt**

Mackinac Island, one of the oldest and most famous tourist attractions in Michigan, nestles between the Upper and Lower Peninsulas where the waters of Lake Huron and Lake Michigan meet to form the Straits of Mackinac. The island was well known to Indians and early explorers more than 300 years ago, and its strategic importance was recognized by the British, who, in 1779, established Fort Mackinac to protect English fur traders from American troops during the Revolutionary War. For the past 200 years, however, it has been the island's scenic beauty that has lured such famous tourists as William Cullen Bryant, Harry S. Truman, John F. Kennedy, and Gerald R. Ford.

In addition to scenery, Mackinac Island has a unique feature that helps to attract over 750,000 visitors a year —horse-drawn carriages are a major means of transportation on the island. No automobiles are allowed. Tourists take guided carriage and horse tours, pedal around on rented bicycles, and take walks along numerous trails. The famous Mackinac Island fudge provides an additional attraction, and local islanders commonly refer to the thousands of tourists who descend daily on the island during the summer as "fudgies."

The island's decidedly turn-of-the-century atmosphere is due to its Victorian architecture and horse-filled streets. But the maintenance of this atmosphere is not without drawbacks. The approximately 500 to 600 horses needed each summer to meet the transportation needs of the increasing number of visitors produce an enormous amount of manure. The manure, in turn, provides breeding sites for two nasty pests, the housefly (*Musca domestica*) and the biting stable fly (*Stomoxys calcitrans*). These flies typically breed in disturbed manure that has been mixed with straw and urine, which in most instances occurs in and around stables and adjacent barns. Despite efforts to dispose of the manure, enough has persisted in recent years to allow the development of intolerable numbers of flies.

Houseflies are more than a simple nuisance to fudge shops and storekeepers. Annual outbreaks of dysentery were once common on Mackinac Island, and public health officials believed the excessive housefly population was a contributing factor. At one time, many of the island's residents used cooking utensils fitted with specially designed fly screens or cages to keep these ubiquitous pests from contaminating food during cooking and dining.

Stable flies also pose a serious problem because of their vicious biting habit. Carriage horses frequently become skittish from numerous bites, and humans are often targets for hungry stable flies.

Both fly species were a part of nineteenth-century life, especially in towns with large concentrations of horses. But filth fly problems, not an appetizing topic, are rarely mentioned in descriptions of American frontier life. How many Westerns have shown John Wayne, Roy Rogers, or Gene Autry fighting off flies in the local saloon?

Despite their lack of historical recognition, dung-breeding pestiferous flies are a potential problem wherever large numbers of livestock are kept in small areas. Prior to 1945, sanitation was the major method recommended for fly control on Mackinac Island. Unfortunately, many livery owners devoted most of their time to the tourist trade and made few efforts to haul manure regularly from stables to the island landfill for disposal. Manure was frequently piled in alleys or dumped inconspicuously along roadsides. Sanitation was often neglected by many who were convinced that it was a waste of time.

In the summer of 1945, the national conference of state governors was scheduled to be held at the island's famous Grand Hotel. This created an urgent need for a fly-free environment. At precisely this time the U.S. Army released the insecticide DDT for experimental civilian use, and a project was quickly developed to test DDT sprays as a potential fly-control method on Mackinac Island.

The project was an immediate success, providing "astonishing" fly control, according to islanders and public health officials. The mayor of Mackinac Island was so impressed with the new "miracle drug" that he set fire to several hundred fly traps at a special ceremony to usher in a new era of chemical warfare against flies. The pesticide treadmill had begun to roll.

DDT was used for fly control until late in 1949 when the fly population showed high levels of resistance to the chemical. This was one of the first documented cases of insect resistance to DDT in the United States. For the next five years, other chemically similar substances, such as methoxychlor, chlordane, lindane, and dieldrin, were used in various combinations with DDT with unsatisfactory results because the flies also developed resistance to these pesticides. Malathion, one of the second generation of chemical pesticides and a common component of widely available house

M. Keith Kennedy

CITY

Courtesy Michigan Travel Bureau

and garden sprays, then came into use. It was used until 1964, when resistance again became a problem. From 1964 until 1977, Cygon (dimethoate), which is in the same chemical group as Malathion, was used exclusively. It was applied with a mist blower every three to four days during the summer.

In 1978, Mackinac Island houseflies tested at the USDA Insects Affecting Man Laboratory in Gainesville, Florida, proved to be five times more resistant to Cygon than a laboratory strain known to be resistant to several other pesticides. Upon hearing this news, the islanders promptly began referring to the two-winged pests as "superflies."

In the past few years, a second serious insect problem developed on the island: an outbreak of the European fruit lecanium scale (*Lecanium corni* complex) that seriously affected many of the shade and fruit trees in the city and in Mackinac Island State Park. In its adult, immobile stage, the lecanium scale (about the size of a large ladybug) uses its sucking mouthparts to draw nutrients out of the tree. The scale's hard, waxy covering protects it from most liquid insecticides.

Trees infested with large numbers of scale lost branches and suffered a general decline in vigor. Plum trees, a favorite host of the scale, were especially hard hit. In the early 1940s, plums were extensively planted on the island, and Mackinac plum jams and preserves became popular in the local area. The scale, once a devastating plum pest in Eastern Europe, appears to have contributed to the plum decline on Mackinac Island during the last twenty to thirty years. Today, most of Mackinac's few remaining plum trees are in poor shape, suffering from the scale and from black knot, a fungal disease.

*Mackinac Island, which lies between Lakes Huron and Michigan, has lured tourists for 200 years. Cars are banned on the island, and visitors walk, ride bicycles, or use the ubiquitous horse-drawn carriages.*

The scale problem, not the flies, prompted the state park personnel to call us in. Normally, lecanium scale is kept at low densities by numerous parasites and predators, but in their absence, scale can quickly increase to damaging levels. Did something on Mackinac Island eliminate or reduce the scale's natural enemies? We asked ourselves this question when first confronted with the problem. After a preliminary investigation of the island's fly-control program, the answer became apparent. The Cygon spray operators routinely directed the mist blower spray into the lower canopies of trees along the control routes in the city and in the state park. A quick check showed that all the scale-infested trees were on or near this route. The scale's natural enemies were being effectively eliminated by the Cygon spray, while the scale itself, susceptible only to dormant oil sprays or applications directed at its crawler stage, was not affected. Released from its natural controls, the lecanium scale in-

Louis Renault, Photo Researchers

POOL
RESTAURANT
BARBECUED CHICKEN TO TAKE OUT
ORNS LIQUOR
PIZZA

M. Keith Kennedy

creased to outbreak levels. The control program directed at a primary pest (pestiferous flies) had induced an outbreak of a secondary, previously unimportant pest, the lecanium scale.

But apart from the scale outbreak, the control program was in trouble. The island was slowly losing its chemical war against flies. The bulging arsenal of new insecticides that existed in the fifties and early sixties was no longer available by the late seventies, and the effectiveness of any new chemical was quickly compromised by the flies' ability to develop resistance. Fly control on the island had reached a point where alternatives to the current program had to be considered if satisfactory results were to be obtained without further upsetting the island's ecological balance.

The city council and the Mackinac Island State Park Commission, which maintains Fort Mackinac and approximately 80 percent of the island's 2,465 acres, jointly sponsored the fly-control program. In 1977, we proposed to these organizations that a new fly-management system be considered. Our proposal emphasized an integrated approach using selected cultural, chemical, and biological control techniques instead of a single control method. We placed the primary emphasis on sanitation—prompt and effective disposal of manure from stables and other potential fly-breeding areas.

Our proposal did not go unchallenged. For over thirty years, residents and seasonal shopkeepers had relied totally on insecticides. Spraying was a relatively low-cost, minimal-labor control method that required little knowledge, cooperation, or energy expenditure by individuals. In addition, many summer residents and local businessmen were interested only in short-term fly-control efforts, and any control program extending beyond Labor Day was of little interest to them. A strict sanitation program placed responsibility with individual residents and businessmen. "The trouble with sanitation is that it might not get done," one of the city councilmen said at a town meeting. "An effective sanitation program would require the city to hire personnel to enforce the sanitation regulations," he said, while chemical control was "like a great big policeman." The councilman was right: a sanitation program required the enforcement of existing or future ordi-

Richard W Merritt

*Part of the island's new pest-control program was to improve sanitation in stables and corrals. Both the stable fly, above, and the housefly breed in the disturbed manure found in these areas.*

nances, as well as cooperation between city and state park personnel and understanding from residents and business persons.

After much discussion, the city council and the state park commission voted to support our program for a one-year trial period. The money previously spent for insecticides and a spray crew was to be used to fund the new, integrated fly-management program in 1978.

We shortly discovered that the islanders generally did not understand where the flies came from or where they were going. The adult fly had been the nuisance stage and the major target for years, and there was little interest in the immature stages or knowledge of where they occurred. The local newspaper reported that one city council member was concerned that the city might be paying Michigan State University personnel to control pests that lived on property owned by the state parks. Our dispersal studies used dye-marked stable flies to show that adult flies were moving freely throughout the island with little concern for property rights. An education program was initiated through newspaper stories, word of mouth, and a short documentary movie, shown at council meetings, that concentrated on the life history (breeding sites, dispersal habits, and so on) of the flies. Once they understood that the major breeding area of houseflies and stable flies was disturbed manure, the residents were more easily convinced that sanitation measures would reduce the adult fly population, and the program received increased support.

In the spring of 1978, we initiated a field study on Mackinac Island to determine adult population densities and major larval breeding sites of the housefly and stable fly. This information was necessary to concentrate control efforts where fly breeding was heaviest and to evaluate the effects of the integrated control program after implementation.

We determined the major larval breeding sites by closely examining horse manure piles, droppings, and organic wastes in and around corrals, stables, feed-storage areas, feeding troughs, and garbage cans and other waste receptacles. In cooperation with Richard Patterson, of the Insects Affecting Man Laboratory, we sampled adult stable fly populations by placing fiberglass panels coated with a sticky material at major breeding sites. The fiberglass panel reflects ultraviolet light in such a way that large numbers of adult stable flies are attracted to it, and the sticky material traps them. These traps have proved extremely effective in providing accurate indexes of adult densities in the field and can also serve as a control device if the panels are treated with an insecticide (for example, Permethrin) instead of an adhesive material. USDA studies have shown that in seven to eight days this method can successfully reduce local stable fly populations around barns by 84 to 90 percent. Because houseflies are not attracted to the fiberglass panels, we used other types of traps containing commercial housefly baits for them.

We also planned to release two species of tiny parasitic wasps, *Muscidifurax raptor* and *Spalangia endius*, to evaluate their potential for controlling flies on the island. Both wasp species attack the pupal stage of the fly, killing the larvae and preventing adult emergence. Just when we felt the program was gaining general acceptance, the local newspaper carried an article entitled "Tiny Wasps Could Replace Insecticides in Combating Flies." This

John Gadia/fpg

*The island's architecture and old-fashioned transportation provide a turn-of-the-century atmosphere. Scouts on the march, facing page, confront another aspect of life before the advent of the motorcar.*

alarmed many residents because they associated wasps with yellow jackets or hornets. Although the wasps involved were small (less than a millimeter long), solitary parasites that attacked only fly pupae, we were often questioned about the size of the wasps or their nest and how injurious the sting was to humans. City and park officials asked if we would need additional money to control the wasps once they controlled the flies. From that time on we referred to the wasps as parasites and emphasized them less than other control measures.

In addition to searching for larval breeding areas and monitoring adult fly population densities, we tested several other control methods on a trial basis. Using a pyrethroid insecticide, we tried localized spraying of major adult fly resting sites, such as sides of stables and manure wagons. Pyrethroids are synthetic versions of pyrethrins, naturally occurring insecticides produced by chrysanthemums and other plants. We did this sort of spraying only in emergencies when adult fly populations reached outbreak proportions.

We also recommended the following sanitation measures to stable and store owners: cleaning manure from barns and stables on a weekly basis; removing fallen feed from cracks in horse stalls and adding rock salt or lime to these sites to prevent larval development; covering all trash cans; providing flyproof screens for store windows and doors; laying a cement floor where manure wagons were parked to eliminate breeding areas and facilitate cleanup; and composting manure to prevent larval and pupal development. Finally we conducted a public opinion survey on the island to better understand reactions of tourists and residents to pest fly problems.

By the end of summer 1978, we had learned a great deal about the fly and people communities on Mackinac Island. We had located and mapped major breeding areas for fly larvae and major adult resting sites. We discovered who was contributing to the fly problem through poor sanitary practices and who was willing to cooperate with the program. Our public opinion survey showed that flies were not as serious a problem to tourists as they were to residents. Of 1,000 tourists surveyed, only one said that the flies would keep him/her from visiting the island again.

Ed Gersabeck, a graduate student who was working with us, established a rapport with many of the islanders and state park and city personnel. He became known variously as the Bug Man or Lord of the Flies, and as the Dear Abby of the island for problems ranging from how to get rid of mosquitoes, horseflies, and no-see-ums (small, biting gnats) to how to kill the bats that lived in the governor's summer house. To date, we are still trying to convince some of the island residents that our role is not that of general exterminator. However, as a result of our initial integrated control attempts during the first year, adult stable fly densities in selected areas declined 25 percent, and the amount of Cygon insecticide applied was reduced from 235 gallons to less than one. Because of this initial success, we were funded for an additional year.

We expanded our pilot control program to the entire island in 1979, using sanitary measures, poison panel traps, localized spraying, and parasite releases. The results were significant: we achieved a 40 to 50 percent decrease in the adult stable fly population throughout the island; housefly populations declined by an estimated 25 to 30 percent. On a larger scale, we completely eliminated the broad area insecticide spray program, which in turn reduced environmental contamination. In addition, we initiated and supported the passage of a strong ordinance that would impose fines on those not complying with established sanitation measures.

The discontinuance of the insecticide fogging was not without negative consequences, however. During 1978–79, there were apparent increases in yellow jacket, mosquito, and horsefly populations, as well as an increase in the lilac leaf miner. These increases, observed mainly by island residents, suggest the nonspecificity of the previous control program.

At the present time, we plan to continue the integrated fly-management program on Mackinac Island this summer. The most important job ahead is training city and state park personnel to take over the program when our involvement ends. The program requires their total cooperation, as well as that of summer residents and businessmen.

The serious ecological problems that resulted from the original chemical control program—increased insecticide resistance in a pest population (housefly and stable fly) and a secondary pest outbreak (lecanium scale)—are not unique to Mackinac Island. In the late 1960s, an intensive insecticide control program for mosquitoes in the California-Nevada resort area of Lake Tahoe led to an outbreak of pine needle scale (*Chionaspis pinifoliae*). More recently lecanium scale outbreaks have occurred in two Michigan cities that regularly fogged their streets with insecticide for mosquito control.

The failure to consider the effects of pest-control strategies on the total ecosystem led to serious consequences in all these situations. As we have demonstrated, however, the use of an integrated pest management approach can provide effective control and is more compatible with our natural environment. ☐

Mackinac Island State Park Commiss

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# Dirty River Turtles

*That Illinois River has its silt,*
*has its sewage, has its turbid waters,*
*but those old turtles just keep rolling along*

### by Don Moll

The Illinois River is comparable to a fine old painting—both are easier to admire from a distance. From the heights of Peoria's Grandview Drive, the river appears as a broad silver band of tranquil beauty, coiling through patches of forest and cultivated fields in great serpentine loops on its slow journey to meet the Mississippi, nearly 175 miles to the south. Drop down from the bluff and stand on the riverbank at Waterworks Park and the idyllic image is quickly shattered by the odor from the bloated bodies of carp and gar washing against the shore. They move on thick, oily green water in rhythm to the backwash tides generated by the barge and motorboat traffic moving continually through the narrow channel. No rooted aquatic vegetation is visible and the only birds in view are grackles and ring-billed gulls, garbage eaters working the bodies along the shore. The Illinois River has not always been so, but unlike the paintings of the old masters, the river has not aged well.

When Pere Marquette first traveled the Illinois Valley in 1673 he wrote, "We have seen nothing like this river that we enter, as regards to its fertility of soil, its prairies and woods; its cattle, elk, deer, wildcats, bustards, swans, ducks, parroquets, and even beaver." Capt. Howard Stansbury, in 1838, described the valley as "one to

James P. Rowan

*The polluted Illinois River flows past Starved Rock State Park near Utica. Smooth soft-shelled turtles, left, have declined in the river because silt has covered the sand bars they need for nesting.*

Werdene Wieser

five miles wide, deeply overflowed in every freshet, filled with bayous, ponds, and swamps, and infested with wild beasts." Throughout the nineteenth and early twentieth century conditions were only little changed from these early descriptions of most of the river and adjacent flood plain. The region was a richly vegetated fish and wildlife paradise, famed for its bass fishing and waterfowl hunting. Weekend trains known as fisherman's specials hauled in carloads of anglers to sample the river's richness, and a diverse array of sportsmen, including President Benjamin Harrison and the gangster Al Capone, shot duck from its shores. A booming mussel fishery supplied pearls and shells for buttons, while commercial fishing provided tons of fish for the markets of Chicago and the cities of the eastern seaboard.

Turtle fishing was also big business at the turn of the century, and an all-time high catch of 547,000 pounds, based mainly on snapping and soft-shelled turtles, was recorded for 1899. The first reference, in 1892, to the quality of the Illinois River as a turtle habitat was given by the naturalist Harrison Garman in a comprehensive synopsis of the reptiles and amphibians known from the state at that time. His judgment of the river's excellence was based on the large number of turtles observed, the extensive sloughs, the numerous sandy shores suitable for nesting, and the ample animal and vegetable life, which provided food and shelter for the resident turtles. Alvin Cahn, author of *The Turtles of Illinois* (1937), remarked similarly that the river's favorable environment of slow-moving water, swampy flood plain lakes, and abundant, sheltering vegetation was responsible for its very large turtle population.

Inevitably though, as the human population of Illinois expanded during the late nineteenth century, the river was increasingly subjected to the pressures imposed by the developing cities along its banks and the clearing and draining of its fertile flood plain for agricultural use. The northern part of the river changed rapidly into an open sewer as Chicago grew and flushed its sewage and stockyard wastes into the Illinois River via one of its tributaries, the Des Plaines. To accomplish this, special canals were constructed, and in 1871, the Chicago River's flow was reversed to carry wastes away from Lake Michigan—the source of Chicago's drinking water—and into the Illinois River system. The resultant effluent flow killed and bloated river fish by the ton, and in a reference indicative of the pollution tolerance of many turtles, albeit with a somewhat uncomplimentary ring to it, E. W. Nelson noted: "In July and August when the water is worst even the mud turtles leave the river in disgust and seek less odorous homes" (Report of the U.S. Commissioner of Fish and Fisheries for 1875–1876).

During the first two decades of the twentieth century the upper hundred miles of the river became practically anaerobic and nearly fishless. In the late summer of 1912, a vertebrate survey near Morris yielded only a few fungused bullheads, a frog, two snapping turtles, and a soft-shelled turtle in water described the year before as emitting foul privy odors and carrying floating, pan-sized, putrescent masses of soft, slimy matter borne up by gases from beneath. The central and lower stretches of the river remained relatively unaffected by these problems, and with improved sewage treatment techniques and regulations, the condition of the upper river improved dramatically. The major destroyer of the old river ecosystem has been a seemingly benign substance—silt.

The slow-flowing Illinois has always had some trouble carrying its load of suspended soil particles. With increased clearing and drainage of flood plain forests and wetlands in exchange for more row crop acreage, an important buffer between the river and proportionately increasing soil runoff has been lost. Channelization of feeder tributaries, urban storm runoff, and flooding of adjacent bare agricultural land during high-water periods have caused a tremendous increase in the suspended soil load of the river. An ex-

Tom Stack and Associates

*Sewage and industrial wastes pouring into the river have depleted oxygen levels. Severe fish kills have resulted, providing abundant food for such turtles as the common snapping turtle.*

tensive lock and dam system has further reduced the silt-carrying capacity of the river by slowing its already sluggish rate of flow, while heavy barge and boat traffic and large bottom-roiling populations of introduced carp function synergistically to keep the river in a constant state of turbid flux.

Not surprisingly, the drastic changes in the river environment have caused great and largely unwelcome changes in the composition and structure of its biota during the span of a turtle's lifetime. Rooted aquatic vegetation has been nearly eliminated from the river and adjacent lakes, and the once rich macroinvertebrate, fish, and seasonal waterfowl faunas have declined accordingly in numbers and condition or have been replaced entirely by more pollution-tolerant forms. The industries dependent upon these populations have crashed with them. Commercial turtling declined as the economic value of the catch fell, and commercial fishermen, the main turtle catchers, looked elsewhere for employment after the fin fishery also sagged.

If by any stretch of the imagination a silver lining can be found in this dark picture, it would have to be based on the remarkably detailed documentation—by aquatic biologists of the Illinois Natural History Survey and its predecessor, the State Laboratory of Natural History—of the changes that have occurred over the last hundred years. From the 1870s to the present day, a distinguished chain of workers—Stephen Forbes, Carl Kofoid, Robert Richardson, William Starrett, Philip Smith, Frank Bellrose, and many others—have watched and recorded in unparalleled detail the demise of the river and its biota, earning the Illinois its title as the "most studied" river in the world. One of the few gaps in this documentation has been the effect of habitat alteration on the ecology of the river's turtle fauna.

Having grown up along the banks of the Illinois River, and from early on a student of turtles and local natural history, I became intrigued by this gap in turtle knowledge and began to search for clues. Cahn's 1937 work was a mine of information on the natural history of Illinois River turtles in the relatively unpolluted period of the early twentieth century, and Phil Smith's treatise on the amphibians and reptiles of Illinois in 1961 gave important distributional information. Largely lacking, however, was published ecological information from the transitional period to the badly polluted modern condition, and on the status and ecology of the present turtle fauna. To solve the former problem, I became a skulker in museum basements, private collections, and the musty storage closets of the Illinois Natural History Survey and other agencies, where specimens, mice, and unpublished information of the old river biologists were housed. For the latter problem, I began trapping the turtles of the river and remaining flood plain lakes and wetlands. After several years of such investigations a relatively clear, and initially surprising, picture of the river's turtle populations during the critical period of change has emerged.

Despite drastic habitat modifications, my trapping campaign of the mid-1970s showed large, thriving populations of painted, red-eared, map, false map (now believed to be composed of at least two morphologically similar sibling species previously unrecognized), spiny soft-shelled, stinkpot, and common snapping turtles still inhabit the river, as they did in the days of Garman and Cahn. On a sunny spring day, logs and stumps near the banks are crowded with the common basking species, serenely unperturbed by the passing stream of river traffic and water skiers. The eastern mud turtle and the alligator snapping turtle, two species apparently always rare in the river, were not collected during my study, and although both may still turn up occasionally, their status remains uncertain.

Three species that were once surely abundant in the river or adjacent flood plain wetlands have weathered the modern changes badly. The smooth soft-shelled turtle and the Illinois mud turtle are probably gone from the modern river ecosystem. Both require extensive areas of clean sand—a habitat largely extirpated from the Illinois River by the choking layers of mud now deposited upon the once common sandy bars and bottoms along its course. Mike Plummer of Harding College found that smooth soft-shells in the Kansas River will not nest on sand bars, the principal nesting sites for this species, if they are covered by silt, even if they were used extensively before coverage. Egg clutches laid before coverage are doomed to failure, probably because the hard, sunbaked surface that develops prevents emergence of the hatchlings entombed be-

Tom Brakefield, Animals Animals

neath. The last museum specimens I could find of this species collected from the Illinois River system came from the lower river and from Chautauqua Lake in 1940, three years before the great spring floods of 1943 and 1944 dumped tons of silt into the river and adjacent lakes, drastically changing their ecological makeup. Unpublished records indicate that smooth soft-shells were present elsewhere in the river at least through 1942 and probably later.

Although unproved, similar factors are probably partly responsible for the decline of the Illinois mud turtle. Laboratory studies I have conducted indicate the mud turtle, more of a pond dweller than the smooth soft-shell, has great difficulty digging into any but loose, sandy substrates. The extensive drainage of the ponds and wetlands of the flood plain and adjacent sand prairies has undoubtedly been a major reason for the mud turtles' decline. David Thompson, the first collector of this turtle in Illinois, reported in the 1920s that he had seen twenty to twenty-five specimens along a ninety-mile stretch of river between Meredosia and Peoria; in 1931, eleven more specimens were collected at Meredosia Bay. I trapped the same stretch of river and the bay for this turtle regularly between 1971 and 1976 without success, but remnant populations still exist a few miles east of the river in semipermanent sand prairie ponds.

The Blanding's turtle, once common in river sloughs and wetlands, has been hurt by rising water levels from lock and dam construction in the thirties, which inundated large areas of flood plain marsh habitat, and by drainage of other remaining wetlands for increased row crop acreage. A few are still present here and there, their brilliant yellow throats making them easily visible when they take a breath at the water surface, but their populations are greatly diminished from those of the early days.

Why these populations declined seems fairly evident, at least qualitatively, but of equal or greater interest to me, and a happier subject to cogitate on, is how so many species have survived, and in such large numbers, the destruction of the old river environment. Even more surprising, analyses indicate that several species resident in the mucky river ecosystem of the 1970s are growing and reproduc-

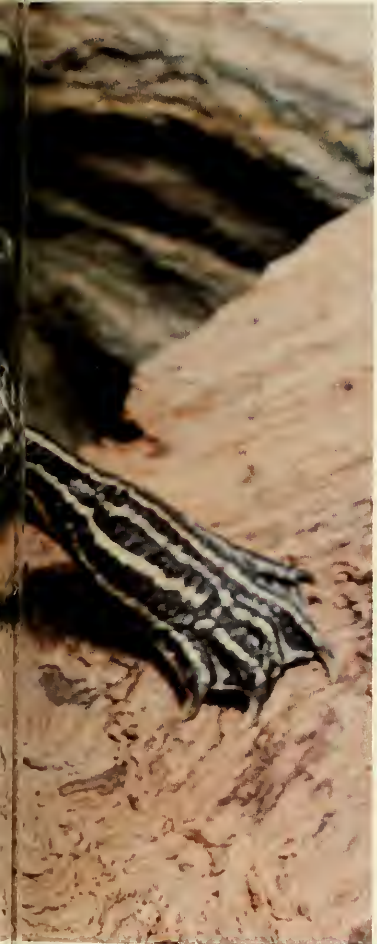
Tom McHugh, Photo Researchers

ing at a faster rate than ever. Some detective work points to the reasons why.

There are no written records of turtle growth rates, and only incomplete reproductive data available from the nineteenth and early twentieth century period, to compare with the current data supplied by my trapping program. A properly preserved turtle, however, can yield a wealth of ecological information, and fortunately many such specimens are available in private collections and museums scattered throughout Illinois. Most were collected incidentally, beginning in the 1870s, during fish surveys by Illinois Natural History Survey biologists, but one particularly valuable group of specimens housed in the musty, plastic-vine-shrouded catacombs of the Chicago Academy of Sciences was collected in the course of state herpetological surveys by Francis Lueth and Phil Smith. Duly recorded and cataloged by location and date of capture, they remained largely untouched until I dug them out in 1976. Through a small incision in front of a hind leg, I could quickly remove the digestive and female reproductive tracts for later analysis, with no apparent damage to the specimen. Growth rings indelibly etched into the plastral shell scutes of many species can be used to calculate growth rates through application of simple formulas. With fragmentary dietary and reproductive data in the early literature and unpublished agency files, and our knowledge of the early river environment provided by INHS biologists, a clearer picture of turtle ecology in the early river and its changes through time emerges.

Turtle survival in the drastically changing conditions of the river and adjacent flood plain lakes during this century is basically a result of the turtle's longevity and its capacity for behavioral and physiological opportunism. Largely independent of aqueous oxygen levels, the turtles have not fallen victim to the modern river's chronic oxygen depletion, which has doomed many fish species. The dearth of rooted aquatic vegetation, once used extensively by the river's turtles for food and shelter, has evidently not affected them much either. The increased turbidity of the water may in part compensate for the lack of sheltering vegetation since a small submerged turtle is virtually invisible to any sight-hunting predator at a distance of only a few centimeters. Also, populations of turtle predators, such as largemouth bass, northern pike, great blue herons, and common egrets, have declined as water clarity was reduced. The loose soil of plowed fields, so abundant adjacent to the river, offers fine nesting areas for most turtle species, and only heavy egg predation by raccoons and skunks seriously limits the hatch.

Another key to the success of many of the turtle species is their ability to eat whatever the river provides. Large populations of maps, paints, sliders, stinkpots, and soft-shells thrive in areas of the river with no benthic macroinvertebrate fauna or rooted aquatic vegetation whatsoever. Drowned insects, bottom mud and detritus, and floating fish carrion make up the bulk of their diet. Many species that were highly herbivorous as adults in the old days are now strict carnivores and detritivores throughout life. Even the morphologically specialized map turtle, which has broad alveolar jaw surfaces for crushing mollusks (a main food source in the old river environment), seems to be doing well on an insect and carrion diet. High-water periods provide easy access to terrestrial vegetation, insects, and other normally inaccessible terrestrial fare. (During a high-water period on the Mississippi River, I collected a big female false map turtle stuffed with red-winged blackbird nestlings.) Fish kills caused



Phil Dotson, D.P.I.

*With the decline of the mollusks on which it was adapted to feed, the map turtle, left, switched to a diet of insects and carrion. The eastern mud turtle, above, is rare in the river.*

by low oxygen levels or severe winters occasionally provide feasts for turtles.

Of major importance to the turtles are localized irruptions of benthic, pollution-tolerant insect larvae populations. Populations of midge or caddis fly species appear regularly enough and in such tremendous density as to provide a reliable, highly nutritious diet for turtles. Once established, these benthic larval populations may be present over a period of years, but can fluctuate widely in density in different years or be eradicated completely for reasons not yet understood. Lake Chautauqua, for instance, had tremendous midge larvae populations in the early 1950s but is now nearly devoid of benthic insect larvae. The false map turtles of the Illinois River specialize in this food resource and are found only in areas where large benthic larvae populations exist. The highest turtle growth rates and reproductive potentials for several species were observed in specimens collected from such areas. Their digestive tracts were usually packed with larvae. Specimens collected from more barren areas usually had much lower growth and reproductive rates. Turtles I collected from Lake Chautauqua in the 1970s had grown more slowly and produced fewer, smaller egg clutches each year than did the available turtle specimens collected from this lake in the 1950s. For example, most painted turtles collected here between 1950 and 1951, when insect larvae were abundant, produced three clutches of about eleven eggs each per year, while specimens obtained from the barren lake of 1975–76 usually only produced one clutch of four to five eggs annually. Several of my other study areas also confirm this relationship of dietary quality with growth and reproductive success, first noted in papers by Whit Gibbons and Donald Tinkle concerning painted turtles of Michigan's badly polluted Kalamazoo River.

An additional food source for some Illinois River turtles has become available in recent years. Since 1970 a pollution-tolerant exotic mollusk, the Asian clam, *Corbicula manilensis,* has extended its range into the Illinois River and is becoming well established. Digestive tract analyses of map turtles from the lower river indicate that the Asian clam is being utilized as a food source and may replace the currently depauperate fingernail clam and snail populations that were once a staple of the map turtle's diet.

Although we can be thankful for this persistent remnant of the old river fauna, we obviously can take little credit for its continued existence. The resident turtles of the modern river exist there in spite of us. They have adapted to current conditions because of their flexibility and opportunism.

*The turbidity of the Illinois River, combined with its silt load, helps obscure immature turtles, such as this red-eared, from predators. This species is thriving in the river.*

Aesthetically, the modern river is a grotesque imitation, a travesty, of its former self, and I am greatly saddened that I can never see what Marquette or Forbes or even Cahn could take for granted.

But, strangely, the lure of the river is still there, and a love for the place is deeply ingrained in those of us who study it or fish it or who have long lived along its shores through the hell and high water to be found there. I believe this feeling for the river stems from our memories, whether first- or second-hand, of what it once was. The vestiges of the good old days may take the form of a pair of wood ducks startled from the riverbank brush or the occasional sauger or northern pike still hooked by river fishermen. For me, however, the sliders and maps lining the logs along the channels and sloughs on a hot, sunny spring day recall the lazy tranquility of the old river as nothing else can. The big old "red ears" sitting there have seen it all; they have watched the place change, and I wonder whether they will cope with the rest of the century as well as they did with what is already past. ☐

M.P L. Fogden; Bruce Coleman

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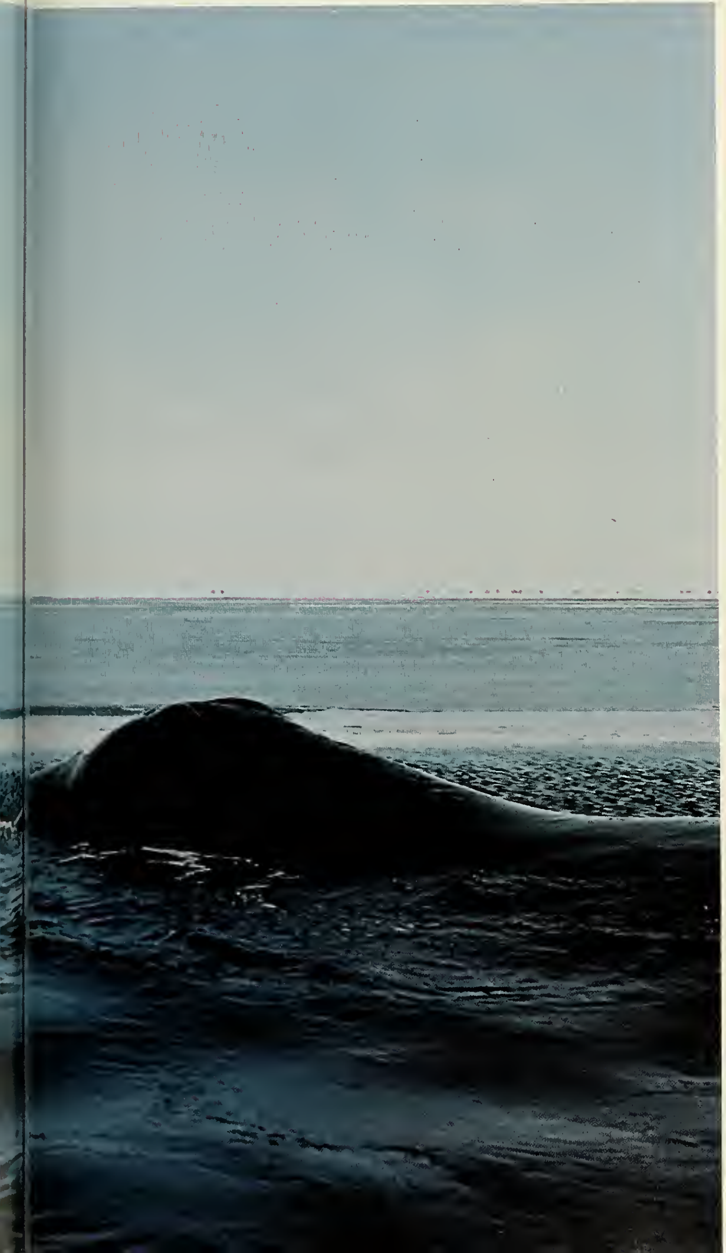
*A whale hunter from the village of Gambell, Saint Lawrence Island, is about to hurl his harpoon into a bowhead. The future of such hunting, and the status of the bowhead, are seriously in doubt.*

# Battle of the Bowheads

*The International Whaling Commission claims there are too few. The Eskimos contend there are enough. At stake is the survival of the whales and a culture*

### by John Bockstoce

Chlaus Lötscher



As he bent over the bow of his whaleboat, knocking the glistening ice from the harpoon line, Luke Koonook's face was expressionless. He ignored the 10 degree north wind that stabbed at his bare hands and worked his way aft along the gunwhale of the eighteen-foot sealskin-covered boat. Five or six of his sons and nephews joined him, and while they worked, I saw each one instinctively flick his eyes at the ink black ribbon of water that separated the shore-fast ice, on which we were standing, from the moving ice pack.

Their faces, too, were impassive in the fierce cold, showing a discipline born of years of arctic hunting; the only indication that they felt the cold at all was a slight change in their stance as they tapped one caribou-skin mukluk against the other, forcing the blood back into their feet.

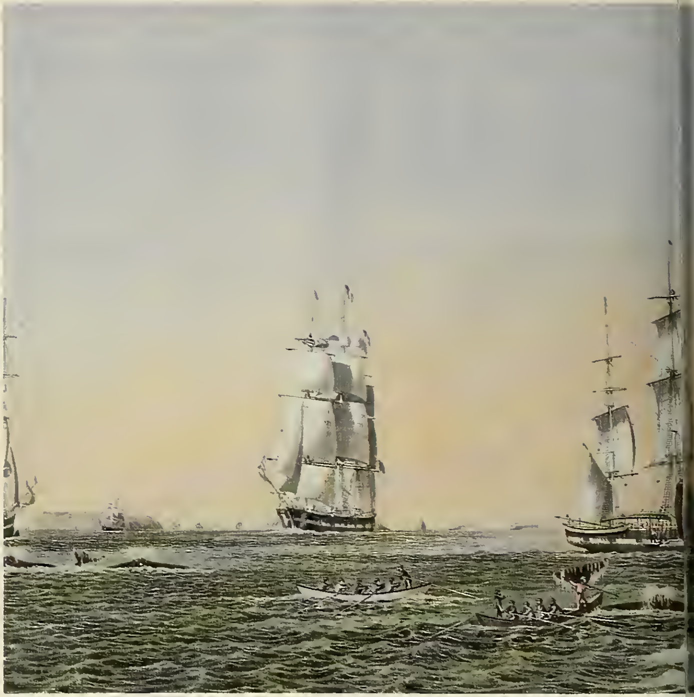
We were one of a dozen whaling crews stationed a mile offshore in the Chukchi Sea near Point Hope, Alaska, where the Eskimos spend two months of each spring waiting for the bowhead whales to swim past on their spring migration from the Bering to the Beaufort seas. The bowheads, some of them sixty feet long and weighing fifty tons or more, follow narrow cracks in the ice along the northwest coast of Alaska from the Bering Strait to Point Barrow. And it is in these waters that the Eskimos have gone whaling for a thousand years.

When the whaling gear was in order, Luke turned to me and brought up a subject we had discussed earlier; clearly, it had been on his mind during the intervening half hour. His eyes were bloodshot and red-rimmed from thirty-six sleepless hours spent paddling after several bowheads, and I could see he was deadly serious.

"If they stop us whaling, I don't know what we'll do. We have no other way of life. Point Hopers are whalers."

He was referring to the International Whaling Commission's (IWC) recommendation that Eskimo whaling should be stopped. Although the IWC

Hugo Poisson, The Kendall Whaling Museum



subsequently modified its stand to allow a small quota, Luke, like most Eskimos, saw the action as a direct threat to his way of life.

Norman Omnik, one of the crew, added, only half jokingly: "Whaling is our Christmas, Fourth of July, and Thanksgiving." He was right. The whale hunt not only provides the Eskimos with a vast amount of food but it is also deeply interwoven with their culture. Their celebration of whaling at important festivals throughout the year reaffirms their cultural unity and uniqueness, their kinship and other social ties, and their close, respectful, and finely balanced association with nature.

"The bowhead is the most endangered of whale species," Ray Gambell, the secretary of the IWC, told me recently. "Further Eskimo hunting could possibly result in the bowhead's extinction. . . . [the IWC] had to act in what it saw to be a desperate situation."

Thus, for the first time, the IWC, which regulates the catch of whales among member commercial whaling nations, has come into conflict with an aboriginal people. Since 1972 the IWC had been issuing increasingly urgent warnings about the Eskimo hunt, but the roots of the problem are far older, reaching back more than two hundred years.

The Eskimos began whaling in northwestern Alaska about A.D. 800. Their whaling developed from a constellation of factors, the most important among them being the acquisition of toggle-headed harpoons and inflated sealskin drag floats. The harpoons held firmly under the whale's skin and the float's retarding force tired a whale as it tried to escape. These inventions allowed the Eskimos to base their hunting economy on the sea's resources—seals, walrus, and whales—which were more reliable and less subject to disastrous fluctuations than those of the land. Using the drag float and improved harpoon head, Eskimos no longer needed to fight an animal directly by holding the harpoon line; instead the float did the work and took the punishment. So practical were these inventions that Yankee whalers adopted them in the nineteenth century, and Eskimos continue to use them today.

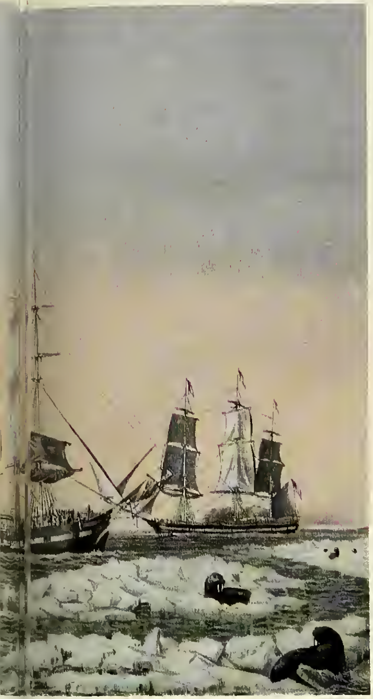
Another, equally important factor was an increasing Eskimo population that allowed each village to send out a number of crews. The catch increased dramatically when the Eskimos hunted in concert and concentrated on one whale at a time. When a whale was towing a dozen or more floats, tired and unable to submerge, it could easily be killed and towed to shore-fast ice for butchering.

Eskimos used all of the whale: skin, meat, and entrails for food; blubber for fuel; bones for tools and building materials; and baleen—the long, flexible plankton-straining plates in the whale's upper jaw—for lashings and craftwork. And they preserved the perishable parts year-round by storing them deep underground in cache pits dug into the permafrost.

In the early nineteenth century, Alaskan Eskimos probably took about forty whales a year, and this vast quantity of food allowed them to live, unlike other Eskimo groups, sedentarily in villages of up to 500 people, developing rich and complex social, artistic, and mythic traditions through which was shot the lore of the whale hunt, its glory and bounty.

But underscoring all was the Eskimos' fundamental understanding that without the whale, their society could not survive. Their palpable fragility was periodically driven home to them in lean years when adverse winds closed the shore leads all spring, forcing the whales far out to sea where the hunters could not reach them.

Despite these fluctuations the Eskimos and the whales lived together in a relatively stable ecosystem, but that stability was destroyed forever by the



*The painting* Right Whaling in the Bering Straits and Its Varieties *depicts different aspects of bowhead (also known as arctic right whales) whaling in the late nineteenth century. Fully loaded with oil, the ship under sail is heading past one of the Diomede Islands on its way to home port. The head of a bowhead is being hoisted aboard the ship in the center, while the ship at far right is boiling a batch of oil. The men in one of the dories are lancing a bowhead at the surface, under the watchful eyes of walruses hauled out on ice floes. Below: The portrait of Capt. Thomas Welcome Roys was taken in the mid-1860s. Note Roys's missing left hand, lost in an accident while experimenting with a rocket harpoon.*

arrival of commercial whaling fleets. Although they did not reach the Bering Strait until 120 years ago, the seeds of the destruction they caused had been sown a century earlier by stirrings within the New England whaling industry. In the 1750s ships first began to carry tryworks—for melting blubber into oil—allowing them to shed the fetters of their shore refining stations and range far into new waters.

They quickly entered the South Atlantic and by the 1790s had rounded Cape Horn. They reached Hawaii in 1819, then Japan, and in 1835 a Nantucket whaleship found whales off the northwest coast of America in the Gulf of Alaska. But by far the most important discovery came in 1848 when Capt. Thomas Roys of Sag Harbor, Long Island, decided to probe the waters of the Bering Strait. With a crew nearly mutinous from fear of the ice pack, Roys sailed his ship past the Aleutians into seas where only a handful of large vessels had ever been. His boldness was rewarded when he reached the Bering Strait and sailed into a field of whales—bowheads so numerous, fat, and docile that he filled

Courtesy of Mrs. David Byington, Aurora, Colorado, and the University of Virginia Press

John Bockstoce

his ship with 1,800 barrels of oil after only a month's hunting. On his return to Hawaii word of his phenomenal success reached the Honolulu *Friend*, a missionary newspaper that whalemen carried round the world. So electrifying was the news that it set off an oil rush to the Bering Strait. Roys's discovery was fortunate for the world's whaling fleets because catches were declining in other seas. For a time the immensely productive whaling grounds of the western Arctic gave the whalers a reprieve. Before the industry's collapse in 1910, whaleships from the United States, Germany, France, Australia, and Hawaii made more than 2,600 cruises there, probably killing more than 20,000 bowheads.

But the waters of the Bering Strait were as dangerous as they were lucrative. In sixty years more than 150 ships were lost to gales, ice, and shoals. The industry was able to accept these terrible losses as long as the price of whale oil remained high and the catches large. But after the Civil War, both declined—oil because of the new petroleum industry and the catches because of the massive overhunting. Smart owners sold their ships; the others turned to walrus to increase their oil returns and in the 1870s nearly extirpated that population by killing as many as 100,000.

Although the whalers had relatively little direct contact with the Eskimos up to that time, their depletion of the whale and walrus stocks had an enormous impact on Eskimo society, and it was to grow greater still. In the late 1870s the price of baleen began to climb steeply, driven up by the fashion industry's call for narrow waists and the consequent need for baleen ("whalebone") as stiffeners in corsets. Because the bowheads produced the largest and finest quality of baleen, the whaling industry redoubled its efforts to catch them.

As the price of baleen rose in the 1880s (it would eventually pass five dollars a pound at dockside, making a fully grown bowhead worth $10,000 in turn-of-the-century dollars), the industry responded in two ways: it introduced steam auxiliary powered whaleships, which could pursue the whales into the farthest corners of the Arctic, and it set up shore-based whaling stations at many points in northwestern Alaska to hunt in the Eskimo fashion during the spring migration.

These last thrusts nearly drove the whales to extinction. Ironically, it was their very scarcity that saved them. As the number of whales declined, the price of baleen rose so high that it stimulated the introduction of cheap substitutes—chiefly spring steel—which quickly undercut the market, bringing it from five dollars a pound in 1907 to seven and a half cents in 1912. With the crash in prices came the industry's death. Soon the Eskimos were once again alone in hunting the bowhead. Although they had the seas to themselves for the first time in more than six decades, conditions were vastly different. There were few whales left to hunt, probably fewer than 3,000, and the Eskimos were now using manufactured whaling weapons—the darting gun and bomb-lance shoulder gun.

American whalemen had developed the guns to help prevent the loss of bowheads, which once harpooned, often escaped into the ice, towing lines, gear, and boats. The darting gun was mounted on the harpoon shaft and fired a small bomb into the whale the moment it was struck; the shoulder gun fired a similar bomb from a distance and aided in killing a wounded whale. Used together, they were effective tools for minimizing the number of "struck and lost" whales.

From about 1920 to the late 1960s the level of Eskimo whaling remained relatively constant with about fifty crews, based in villages from Saint Lawrence Island to Point Barrow, taking about ten to fifteen whales a year. The situation changed abruptly in the 1970s when the number of crews and whale catches began to increase dramatically, rising roughly threefold by 1976. Before this time the number of crews had been limited by the high cost of outfitting and maintaining them. But with the boom in Alaskan construction projects, particularly the trans-Alaska pipeline, it became possible for an ambitious Eskimo to earn the $9,000 or so necessary to buy the darting and shoulder guns, bombs, harpoons, floats, lines, boat, sleds, Skidoo, tent, stove, and food and thus to attain the prestigious position of whaling captain.

But the changing character of Eskimo whaling did not go unnoticed, and as the whale catch began to rise, so did scientists' and conservationists' concern about the impact on the bowheads. In particular, they worried about the unknown, but at least proportionate, increase in the number of

John Bockstoce

*On the ice a mile off Point Hope, Alaska, in the Chukchi Sea, Eskimo hunters watch and wait for bowheads passing on their spring migration from the Bering to the Beaufort seas. Up to a dozen native whaling crews from villages in the area participate in the annual hunt. With the use of such manufactured weapons as the darting gun and bomb-lance shoulder gun, the Eskimos have the potential for taking more bowheads than they ever have in the past.*

wounded whales—those struck and lost by darting or shoulder guns—that were not retrieved, many, if not most, of which are assumed to die.

As the catch rose in this decade (it reached 48 whales in 1976 with another 43 known to have been wounded; 28 and 77, respectively, in 1977), the Scientific Commitee of the IWC issued repeated warnings about the possible consequences of the increasing hunt. In 1976 it underscored its concern by passing a resolution asking the United States to reduce both the catch and the loss, but the United States took no important action regarding this request.

Then in 1977, with international sentiment rising against the uncontrolled bowhead hunt, the IWC voted to rescind the Eskimos' exemption from the otherwise total ban on bowhead whaling that had been in force since 1931. Ray Gambell wrote, "Clearly this was a drastic measure but the evidence presented by the scientists indicated that there was a real risk that the expanded slaughter of the bowhead whales, many of which were going to waste, would lead to the extinction of the stock within the foreseeable future."

Before 1977 the U.S. government apparently did little to keep the Eskimos abreast of developments in the IWC, so when word reached them in June 1977 of the IWC's decision, their reaction was sharp and angry. They claimed the action tampered with their domestic affairs and abrogated their inalienable native hunting rights.

Belatedly, in September 1977, the government began a series of public hearings to invite suggestions and criticism. One proposal called for distributing free beef to the Eskimos so that they would not have to shift their hunting pressure to the already depleted caribou herds. The Eskimos retorted that their nutritional needs are only half the problem; that equally important is their whole cultural matrix within which whaling plays a fundamental part; that removal of the whale hunt would result in starvation of another sort.

At the root of all the arguments was the central question of the number of bowheads alive today. Because very little is known about the whale's present or former numbers (it is the least known of all the great whales), the arguments for and against Eskimo whaling often return to one conjectural point or another. I know of no Eskimo who would question the importance of maintaining a viable bowhead population, yet few accept the U.S. government's most reliable current estimates of about 2,200 whales.

The IWC's action and the Eskimos' rebuttal put the government in an awkward position. During the summer and autumn of 1977 it became increasingly clear that the United States would have difficulty in resolving the contradiction between its previously strong stand in favor of whale conservation (the Marine Mammal Protection Act of 1972 is one expression of this) and the Carter administration's support for human and minority rights.

As a signatory to the conventions that established the IWC, the United photos by John Bockstoce

States is bound to carry out the IWC's recommendations within its boundaries, unless it files a formal objection to the action within ninety days of notification. To have accepted the 1977 recommendation would have meant halting Eskimo whaling: to have objected would, according to conservationists, have squandered the progress that had been made through the government's support of whale conservation.

The political atmosphere in Washington was highly charged in September and October 1977 as the antagonists waited for the government's response. Groups at high levels in the State Department (the government's representative on the IWC), the Department of Commerce (with responsibility for marine mammals), and the Department of the Interior (representing Alaska natives) debated the government's action.

On October 21 United States District Court Judge John J. Sirica, acting on a request from the newly formed Alaska Eskimo Whaling Commission, issued a temporary restraining order requiring the State Department to file a formal objection to the IWC's recommendation. But on the day before the ninety-day period expired, the State Department was able to have Sirica's order reversed by obtaining a ruling from the Circuit Court of Appeals in Washington. Finally, within hours of the deadline Chief Justice Warren E. Burger of the Supreme Court upheld the ruling of the Appeals Court by refusing to consider the document.

The government then sought the

*On the chase, a crew, far left, paddles after a bowhead they have spotted in the vicinity. After the whale has been harpooned and killed, cooperating crews gather around the floating carcass, left. The whale's flippers are tied together, below, to facilitate towing the dead animal to a spot where the butchering will take place. The skin, meat, and entrails will be used for food, the blubber for oil, the bones for tools, and the baleen for lashings and craftwork.*

only middle ground available, proposing a bowhead quota of fifteen whales caught or thirty struck, whichever came first, as well as the development of a strong research program to learn more about the whales' biology and numbers. In December the IWC rejected the proposed quotas and agreed to a limit of twelve caught or eighteen struck.

The Alaska Eskimo Whaling Commission observers at the meeting quickly protested the quotas, claiming they were insufficient to meet the nutritional needs of the whaling villages. At least one observer predicted that the quota would be violated, but most agreed to abide by it to demonstrate their good faith, their ability to regulate themselves, and their strong desire to participate in the formation of new regulations.

They were largely successful. Although the village of Barrow exceeded its quota by one whale, the Eskimos stayed within the overall limits. At the June 1978 IWC meeting the United States presented its estimate of the bowhead population, 2,260 whales, with the caveat that the counting program is in its infancy and that more surveys must be conducted before full reliance can be placed on the figures. And the IWC, expressing sympathy for the problems of the Eskimos, increased the quota to eighteen whales caught or twenty-seven struck for the 1979 season.

Nevertheless, in July 1978 the Eskimos of the North Slope Borough (comprising the whaling villages north of Kivalina) brought suit against the government, claiming that the regulations

John Bockstoce

Chlaus Lötscher

were illegal because the IWC convention was not established to include aboriginal whaling. In early 1979 the court dismissed the action, stating that the convention was a matter of foreign policy, hence outside its purview. The Eskimos appealed the ruling in the Ninth Circuit Court of Appeals, where the case remains as this is being written.

Then in February 1979 the IWC and the Department of Commerce, wanting to understand the issues more fully and to seek equitable solutions, jointly convened an international group of scientists to study the questions. The scientists (specialists in arctic biology, anthropology, and nutrition) concluded that although there was no credible scientific basis for allowing *any* bowhead catch, and although alternative sources of food are available, whaling is so culturally important to the Eskimos that it should be allowed to continue at some level.

Although the Eskimos, the IWC, and the U.S. government temporarily achieved an uneasy *modus vivendi*, it did not last long. During the spring of 1979 there was a growing wave of sentiment among the Eskimos—by no means uniform, but centered particularly in Barrow—to ignore the IWC quota and to accept the Alaska Eskimo Whaling Commission's contention that forty-eight whales are a safe and desirable number to harvest. (The Eskimos apparently reached this figure through a tactical blunder by Richard Frank, U.S. commissioner to the IWC, who stated that a harvest of 2 percent of the total bowhead population was a reasonable figure—an assertion strongly denied by many scientists.) But the 1979 season turned out to be poor, and the Eskimos were unable to reach even the IWC quota, thus deferring the issue until 1980.

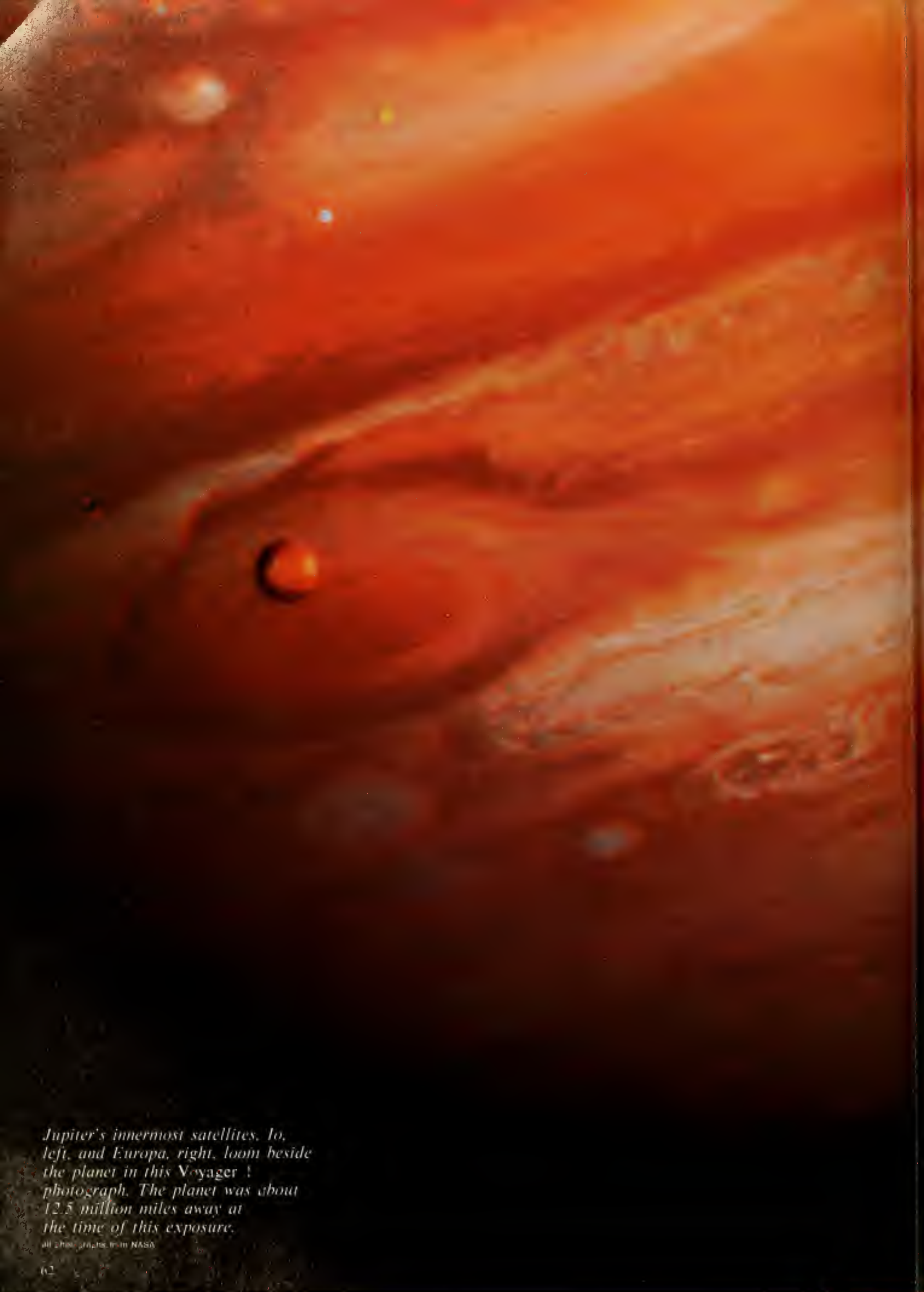
If the Eskimos exceed the IWC quota in 1980, the government will be in an extremely difficult position—and one it is possibly unprepared to deal with. Hitherto, the government seems to have been preoccupied with the relatively noncontroversial questions of counting the whales and of sponsoring other basic research, but equally, it seems to have ignored the serious social dilemma of the bowhead issue by assuming that, if need be, law enforcement can ultimately control the problem.

Conventional law enforcement is, of course, based on a general public acceptance of laws and a disapproval of lawbreaking. In the bowhead problem, however, the government confronts a society that has, on this issue, lost most of whatever confidence it once had in the government; to many Eskimos the issue is increasingly seen as racial. Some law enforcement officials concede that it would be exceedingly difficult to enforce any laws regarding whaling in northern Alaska.

What will happen this month and what the government's response will be remain to be seen. But one thing is certain: the bowhead whale issue is far from settled and beyond it lies the broader question—as yet unanswered—of the rights of Native Americans versus those of all Americans regarding the maintenance of wildlife and ways of life, together, in a shrinking world. ☐

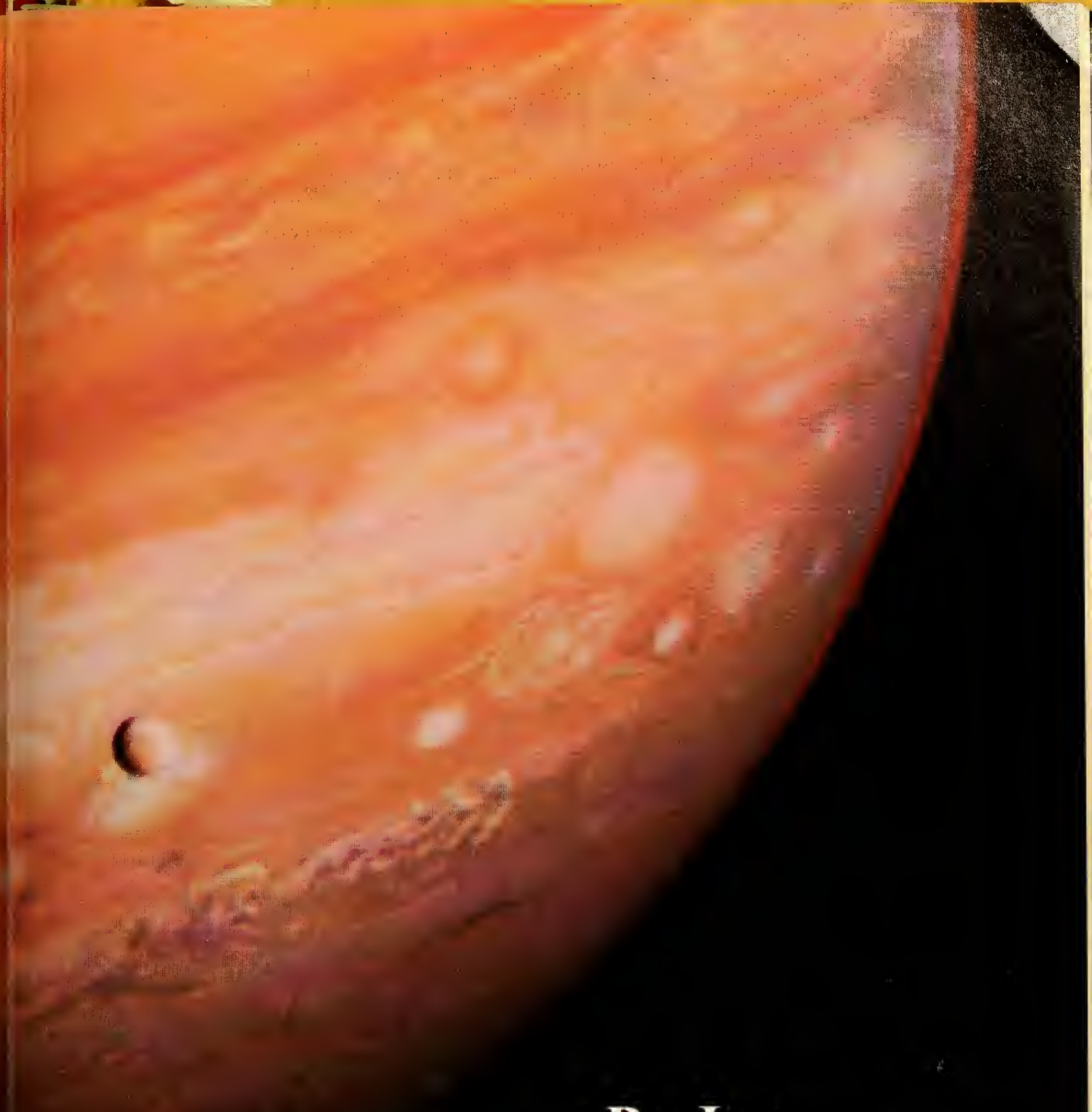
Chlaus Lötscher

*Using pulleys, whalers from the Point Hope area haul the carcass of a bowhead onto the shore ice, far left. The butchering begins with the skin being sliced in a pattern of even strips, left and below; in this case by hunters from Gambell. As important as the meat and other products derived from bowheads is the actual hunt. The activities that accompany whale hunting are deeply woven into the matrix of Eskimo culture, reaffirming cultural unity and kinship and other social ties.*



*Jupiter's innermost satellites, Io, left, and Europa, right, loom beside the planet in this Voyager 1 photograph. The planet was about 12.5 million miles away at the time of this exposure.*

all photographs from NASA



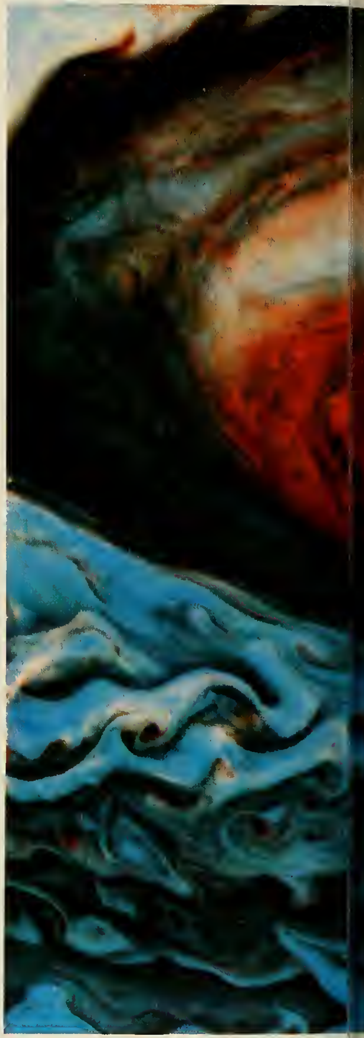
# By Jove

*Photographs and data from the* Voyager *spacecraft that flew past Jupiter yielded several surprises about the planet and its satellites*

### by Andrew P. Ingersoll

The two *Voyager* spacecraft that flew by Jupiter in March and July of 1979 discovered several unanticipated things: a many-particle ring close to Jupiter, a new satellite at the edge of the ring, active sulfur volcanoes on the satellite Io, lightning and auroras on Jupiter (the latter generated by particles from Io's orbit), and turbulence that acts to increase rather than decrease the energy of Jupiter's large-scale cloud motions. Besides their intrinsic interest, these discoveries help us understand related phenomena on the sun, the earth and other planets, and provide clues about how the solar system began and how it is evolving.

Sending a spacecraft to Jupiter is



*The Great Red Spot, an atmospheric storm about twice the size of the earth, and the turbulent clouds around it are shown in exaggerated color. The bluish oval at the bottom is a smaller storm system.*

like sending one to another solar system, something astronomers would like to do but haven't done yet. Jupiter, the giant planet, resembles the sun in many ways. Both release heat internally, although by different mechanisms. Both are fluid rather than solid objects, with complicated patterns of surface flow features. The same elements—mainly hydrogen, helium, carbon, oxygen, nitrogen, and sulfur—are present on both objects in nearly the same proportions. Jupiter has fourteen known satellites; the sun has nine major satellites (the planets) and many minor ones (comets and asteroids). And both Jupiter and the sun have left records in the surfaces and bulk properties of their satellites that tell of violent early histories.

It was known before *Voyager* that Jupiter is mostly hydrogen. No other substance has such a low density for an object of such large size. Jupiter's density is only slightly greater than that of water and is about one-quarter that of the earth. The next most abundant Jovian element, helium, contributes about 20 percent of the planet's mass; all other elements together contribute an additional 5 percent.

Jupiter's internal heat had been detected from high-altitude aircraft before *Voyager*. More refined measurements by *Pioneer* and *Voyager* spacecraft confirmed calculations based on the assumption that this energy was trapped when Jupiter formed. This confirmation lends support to the idea that both Jupiter and the sun started as dispersed clouds of dust and gas 4.6 billion years ago. High temperatures were generated as the material fell inward. On the sun, nuclear fusion released additional energy as hydrogen atoms began sticking together to form helium. On Jupiter, internal temperatures were never high enough for nuclear fusion to occur, but enough heat was generated to last into the present era. The fact that Jupiter now radiates between 1.5 and 2.0 times the energy it receives from the sun agrees well with theory.

Another current idea about solar system formation is that high temperatures on the early sun determined the composition of the planets. An object forming from a collapsing gas-dust cloud is thought to pass through a violent early phase. During this phase, gas and volatile ices are driven from the region near the central body—the sun. Satellites (planets) forming from material in this region are made of metals and their oxides. Satellites forming farther away are made of the more abundant gases and ices. This accounts qualitatively for the differences between the rocky inner terrestrial planets and the gaseous outer planets of the solar system. It also accounts for density differences between Jupiter's four large satellites—Io, Europa, Ganymede, and Callisto—also known after their discoverer as the Galilean satellites.

The density of a satellite-sized object is largely a function of its composition. Metals are the most dense, followed by metallic oxides (rocks), then ices and liquids, and finally, gases. *Voyager* determined the mass of each Galilean satellite by measuring its gravitational pull. The volume was determined from *Voyager* images. These observations confirmed earlier inferences that the innermost Galilean satellites, Io and Europa, are mostly rock, while the outer satellites, Ganymede and Callisto, have increasing proportions of ices and liquids. Because hydrogen and oxygen are abundant elements, water is likely to be the plentiful ice on the outer Galilean satellites.

Thus *Voyager* lent support to the idea that the sun and planets formed simultaneously from a cloud of dust and gas. Star formation by this process seems relatively common throughout the universe. Therefore, by inference, planetary formation is also relatively common.

Planetary rings provide further clues to the origin and evolution of planets and satellites, so *Voyager*'s discovery of Jupiter's ring is potentially significant. Material that is orbiting a planet can pull itself together to form a satellite unless the competing pulls of the planet's gravity and centrifugal force due to orbital motion are too strong. Rings form from material that is inside the so-called Roche limit, where the two competing effects balance each other. Saturn's ring consists largely of snowball-sized chunks of water ice, gently rubbing together as the inner material slowly overtakes the outer material in its orbital motion. Collisions long ago damped out any large out-of-plane motion. Since snowball-sized particles have stable, long-lived orbits, Saturn's ring, at least, could be as old as the planet itself.

Jupiter's ring by comparison is exceedingly thin—it was only discovered when the *Voyager* spacecraft's imaging system took a picture showing the ring edge-on. In this configuration the light rays traverse the maximum possible path through the rings, and the contrast between the ring and space is greatest. Although snowball-sized particles cannot be ruled out, most of the

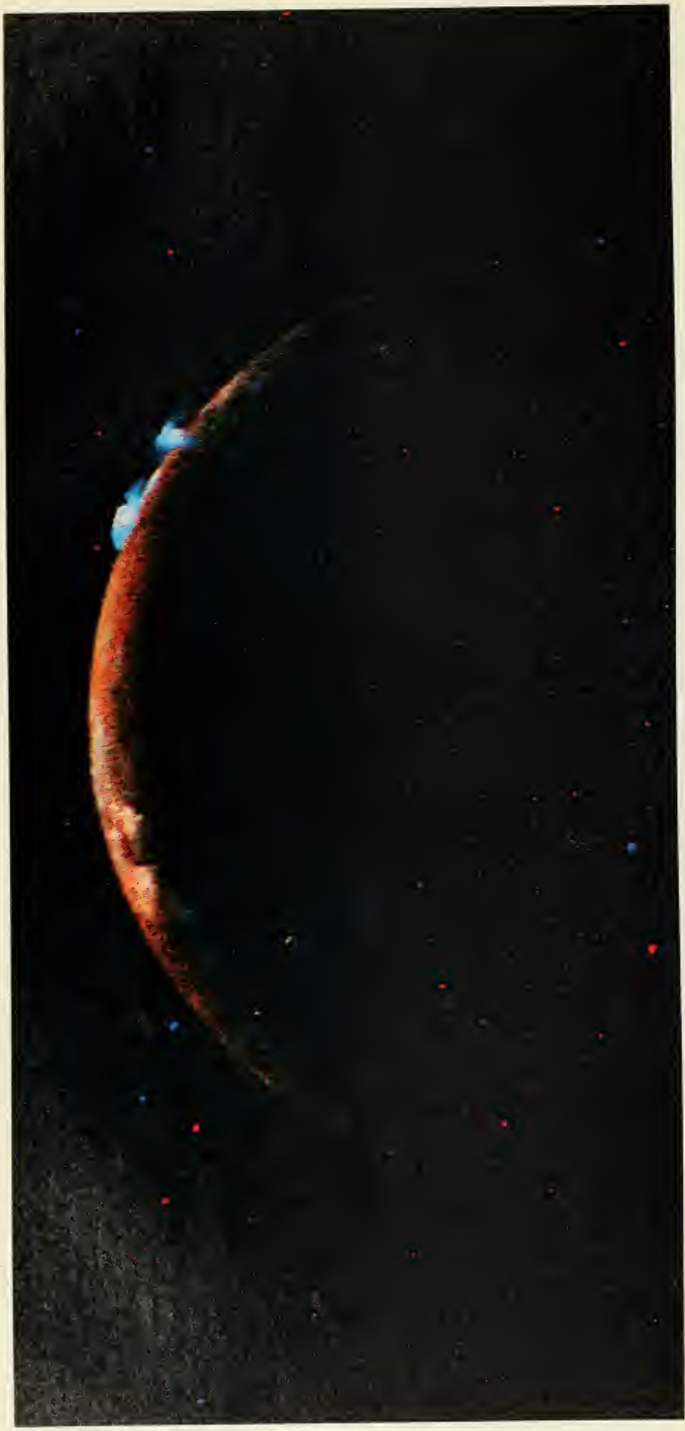
particles appear to be small, about one ten-thousandth of an inch in size.

These inferences are based on the way the rings scatter sunlight. Particles of this size are subject to light pressure and other small forces that cause their orbits to decay. Eventually the particles spiral in to the planet's atmosphere and are lost. These particles cannot be as old as Jupiter itself.

*Voyager* also discovered a small satellite orbiting right at the outer edge of the ring. The satellite undoubtedly helps to sharpen this edge and fix its location. The satellite might also be the source of material for the ring, which could therefore be a secondary object, owing its existence to the small satellite discovered by *Voyager.*

During the final stage of planetary formation, as the last large objects were swept up by the planets and satellites, planet surfaces were bombarded by these large objects at high velocity. Many planets and satellites still bear the scars of this last phase of planetary accretion. The moon, Mars, and Mercury all have terrain that is entirely covered by craters. Evidence that these surfaces are ancient comes from the current rate of formation of craters, which is far lower than that required to cover these surfaces in the time since the solar system began 4.6 billion years ago. Obviously, the cratering rate was higher when the planets were still accreting material. It is now believed that this heavy cratering phase lasted for less than 10 percent of the current age of the solar system. Regions that are not saturated with craters were presumably "resurfaced" after that period ended.

*Voyager* images of the four large Jovian satellites clearly show an increase of surface ages as one proceeds outward. That is, the number of craters per unit area increases with distance from Jupiter. Since all the satellites are thought to have formed at the same time, with the same heavy flux of



impacting bodies, the differences in surface ages must reflect the different rates of burial of features.

By the above reasoning, the outermost large satellite, Callisto, is an inactive body whose surface hasn't changed for 4 billion years. The next satellite, Ganymede, shows a mixture of surfaces, some heavily cratered, and some bearing evidence of more recent faulting and other internal activity. The third satellite inward, Europa, is crisscrossed with linear bands of internal origin, but has only a small number of craters (three were seen by the *Voyager* cameras). Interestingly, the earth has about the same density of impact craters in this size range, approximately ten miles in diameter. The low density on earth probably reflects the effects of erosion and sedimentation in obliterating ancient features.

Jupiter's innermost large satellite, Io, has no visible craters. Assuming a flux of impacting bodies today that is similar to that on the earth, the rate of burial would have to be at least one inch in twenty-five years in order to bury the craters that would otherwise be visible. This would be a high rate of burial for an object such as our moon, which has no atmosphere or active volcanoes. The difference between Io and our moon is undoubtedly related to the active volcanoes and other geologic activity discovered by *Voyager* on Io.

Current understanding of this high activity has come partly from theory and partly from new knowledge of the environment around Io. Both the gravitational and magnetic fields of Jupiter are important. A small object in orbit around Jupiter would be in a weightless state and therefore would experience no internal stresses due to Jupiter's gravity. However, a satellite-sized object experiences different amounts of gravity at different locations about its surface and interior. This differential pull accounts for the tides, and tides are very powerful on an object like Io. It was recently pointed out that the other Jovian satellites cause Io to bob up and down in Jupi-

*Volcanic eruptions on Io, some with plumes almost 200 miles high, were first found by Voyager 1. This evidence of volcanic and other geologic activity on the satellite was unexpected.*

ter's gravity and therefore to experience large changes in the tidal forces. Io's tidal flexing creates heat, which presumably has melted the satellite's interior. The heat escapes when molten material and hot volcanic gases reach the surface. Eruptions of eight active volcanoes were observed on Io by *Voyager*.

In addition, Io is subjected to steady bombardment of ions and electrons that are trapped in Jupiter's powerful magnetic field. This magnetic field is tied to Jupiter, and rotates with a ten-hour period. At Io's orbit, the speed of rotation is huge, thirty-five miles per second. This causes large electric currents to flow in the vicinity of Io, either through the satellite itself, through its tenuous atmosphere, or through the doughnut-shaped torus that constitutes its orbit around Jupiter. These electric currents can also cause heating, which may acount for some of the obliteration of surface features. In contrast, the earth's moon orbits well outside the influence of the earth's magnetic field and so is spared the electrical phenomena that Io experiences.

The activity at Io causes other problems for that moon-sized object. Whereas Jupiter's outer satellites have retained large amounts of water, Io has literally been "cooked" to a point at which only relatively less volatile substances remain to power the volcanoes. One such substance is sulfur. The rich colors of Io are probably due to sulfur molecules. *Voyager* identified sulfur dioxide frost in the spectrum of light reflected from the surface. Presumably this frozen crust gradually thickens as more material is ejected from the volcanoes, and eventually melts under its own weight to form a sulfur dioxide ocean. Io's internal heat, generated by tides or electrical currents, then vaporizes the sulfur dioxide, which breaks through the icy crust and erupts again as volcanic gas. The expansion of the gas is strong enough to send plumes almost 200 miles high into the partial vacuum around Io, but not strong enough to cause a major part of the gas to escape Io's gravity. A substance such as water, which is more easily destroyed in space, would presumably have escaped long ago under these conditions.

Still, some of the sulfur does escape. Light from electrically charged sulfur was detected by *Voyager* coming from the torus defined by Io's orbit. This tenuous ring of charged particles, with Jupiter at its center, seems to be the source of huge auroras that cause Jupiter's atmosphere to "glow" in ultraviolet light. The sulfur ions and their electrons are driven by electrical forces down the magnetic field lines from Io's torus into ring-shaped zones at Jupiter's north and south poles. The role of the sulfur torus was not anticipated before *Voyager*. On the earth, auroras are also due to the impact of charged particles from outside the atmosphere, but those particles originate on the sun rather than on the earth's moon.

The other Galilean satellites may also have oceans beneath their icy crusts. As mentioned earlier, their bulk densities suggest that the proportion of lighter substances such as water is greater for the satellites farther from Jupiter. Io's bulk density is basically the same as rock, and rocky mountain ranges protrude from the flat, frozen crust of the sulfur or sulfur dioxide ocean. In contrast, the outer satellites have extremely subdued topographic relief. The craters on Callisto and Ganymede do not have high, raised rims and deep central depressions like those on the moon and Mercury. The outer satellite craters are made visible by variations in color and texture of the material that was posed by the impacting events. This lack of topographic relief indicates a weak crust at the time craters were forming and is consistent with the hypothesis of a high ice-to-rock ratio for these satellites.

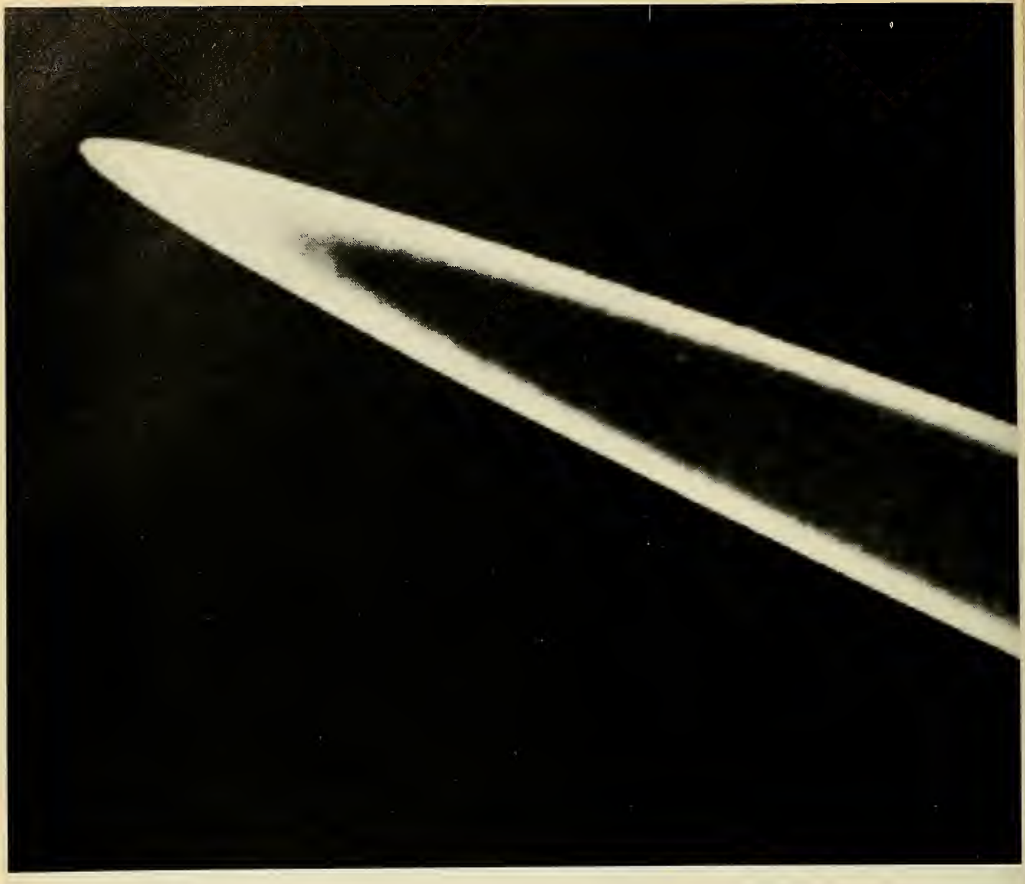
Jupiter itself exhibits a rich variety of surface markings, all having to do with the dynamics of the atmosphere. Every visible feature is a cloud. The solid surface, if there is one, is just a rocky core about one-eighth the size of the planet. Only the minor atmospheric constituents can condense to form solid or liquid cloud particles that are visible in a photograph. And only a small fraction of the condensates are colored. The most abundant condensing substances—water, ammonia, and ammonium hydrosulfide—form white crystals when they condense. Thus color is a subtle process on Jupiter, involving minute amounts of trace constituents. Yet color is one of the spectacular features of the *Voyager* images.

Again, as on Io, sulfur is a prime candidate as the coloring agent. Images of Io and Jupiter together show many of the same colors. However, in a hydrogen-rich atmosphere, most of the sulfur is tied up as hydrogen sulfide gas. This chemical equilibrium is constantly being disturbed by several processes that have sufficient energy to break the bond of sulfur and hydrogen. One of these processes is lightning, which was discovered by *Voyager* in photographs of Jupiter's night side and in the electromagnetic emissions that propagate out of the atmosphere. Another is ultraviolet radiation from the sun striking the top of the atmosphere. A third is the charged particle flux from Io and Jupiter's magnetosphere. And a fourth process that can alter the chemical composition is rapid transport of material from great depths and high temperatures in Jupiter's interior. Besides sulfur, other colored substances that are produced in these ways are phosphorus and organic (carbon) compounds.

There is strong evidence that Jupiter's different colors are associated with clouds at different altitudes. In some regions the dominant vertical motion is upward, causing white and red clouds to form, while in other regions the dominant motion is downward, causing brown and blue colors.

The above processes make colors, but do not account for the large-scale patterns of color or the long lifetimes of the patterns. For instance, the Great Red Spot has been in existence for more than 100 years, and may be the same feature reported by astronomers using the first telescopes 300 years ago. The three white ovals in a latitude band to the south of the Red Spot formed about forty years ago and have changed little since that time. And the large bands that circle the planet at constant latitude are also very stable. These bands—dark belts and lighter zones—change their appearance in time periods of months to years, but on the average their positions and widths are stable.

This long-term stability is remarkable for atmospheric features that are not directly tied to a solid surface. Observations by *Voyager* of vigorous turbulence on small scales only heightens the mystery. For example, small spots circle the Red Spot with periods of six to ten days. Features in the disturbed region to the west of the Red Spot last only one or two days. At all latitudes the dominant pattern of motion involves counterflowing eastward and westward currents alternating in latitude. Small spots caught between two such currents roll like ball bearings with periods of several days. It is remarkable that any features can last



*This thin ring around Jupiter was discovered by* Voyager 1. *It contains tiny particles of about one ten-thousandth of an inch in radius.*

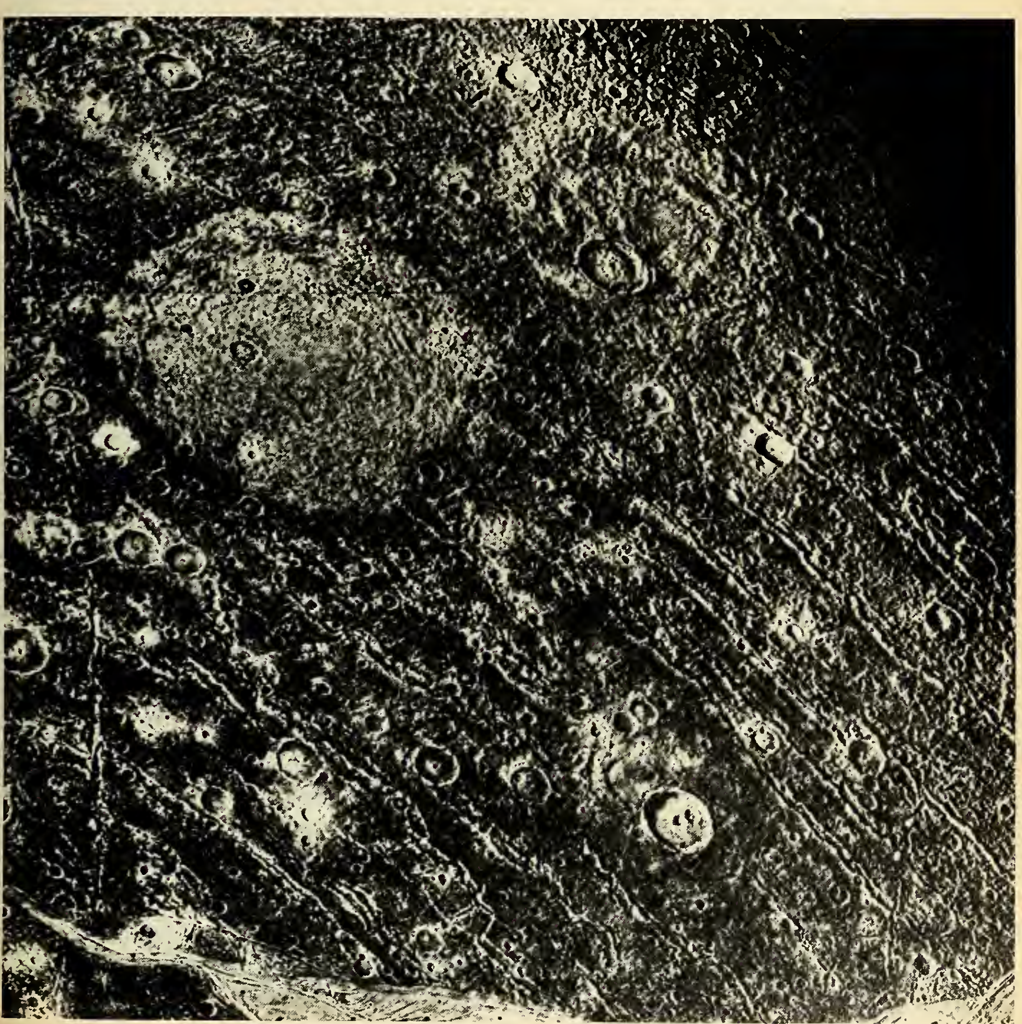
longer than the turbulence itself, that is, longer than several days.

The motions described above are all measured relative to Jupiter's rapidly rotating interior. The winds reach speeds greater than 300 miles per hour. As on the earth, the rotation of the planet as a whole plays an important role in the dynamics of these features. Spots whose rotation is clockwise in the Northern Hemisphere or counterclockwise in the Southern Hemisphere are high-pressure regions—at least at the cloud tops where motions are observed. Spots whose rotation is opposite are low-pressure regions. These highs and lows at the cloud tops may be caused by expansion or contraction of the gas underneath. In this respect, the large high-pressure systems on Jupiter resemble such low-pressure systems on the earth as extratropical cyclones and hurricanes. Both systems are formed by the vertical motion of warm air at their centers. The presence of a solid surface underneath accounts for the differences in the circulations at high altitudes. On the earth, rising air is not immediately replaced at the surface, and a low pressure area forms. On Jupiter, rising air is immediately replaced from below; the incoming air lifts the column and causes high pressures at high altitudes.

The above qualitative associations are confirmed by temperature measurements made by instruments on the *Voyager* spacecraft. The explanations do not, however, account for the long lifetimes or banded appearance of Jovian atmospheric features. This problem has not been solved, but the answer may lie in the absence of a solid underlying surface and in the presence of an internal heat source.

Careful study of the eddy motions divulged in sequences of *Voyager* images has revealed that the short-lived Jovian eddies do not destroy the large-scale structures. It was discovered that the eddies transfer their kinetic energy into, not out of, the counterflowing east–west currents. Presumably this energy is dissipated to heat when the currents rub against the layers underneath. The energy for the eddies must come from another source, in this case the buoyancy of hot and cold parcels of gas. Such a transfer of energy also seems to maintain the earth's mid-latitude jet streams and some of the major ocean currents such as the Gulf Stream in the Atlantic and Kuroshio in the Pacific. However, terrestrial ocean currents owe their permanent configurations to continental boundaries, and the earth's atmospheric jet streams meander over wide ranges of latitude. Thus it is surprising that Jupiter should have as many cloud bands as are observed and that they should occupy such permanent locations.

Evidence that the Jovian currents may extend deep into the atmosphere beneath the clouds comes from the fact that the cloud colors and visible markings change more than the currents do. Observations of the motions of large spots go back over seventy years. Owing to lack of suitable features for tracking, not all Jovian currents are visible from the earth at any one time. Nevertheless, virtually every major current that has ever been seen in seventy years of earth-based observations is visible in any ten-hour sequence of high-resolution *Voyager* images. The cloud bands, however, change their appearance and color on a time scale of a few years. For instance, dramatic changes occurred in the clouds during the four to five years between the *Pioneer* spacecraft encounters and the *Voyager* encounters, yet the latitudes of the currents did not change. Thus the differences between Jupiter and the earth with respect to longevity of flow patterns may be due to the great mass and huge inertia of the deep atmospheric motions below the Jovian clouds. The role of the deep atmosphere remains one of the major unknowns in the study of Jupiter's atmospheric circulations. ☐



*Ganymede, the third of the Galilean satellites, as seen from a distance of about 53 thousand miles, exhibits a variety of impact craters of different ages. The brightest craters are the youngest.*

# Jefferson Davis's Camel Corps

*The feasibility of a camel cavalry was tested in the southwestern United States*

**by Gerald Carson**

In the late 1840s a group of junior army officers engaged in protecting the southwestern frontier of the United States—a mountainous terrain deficient in the grass and water needed by cavalry horses and pack mules and recently doubled in length by the annexation of Texas—began to think about camels.

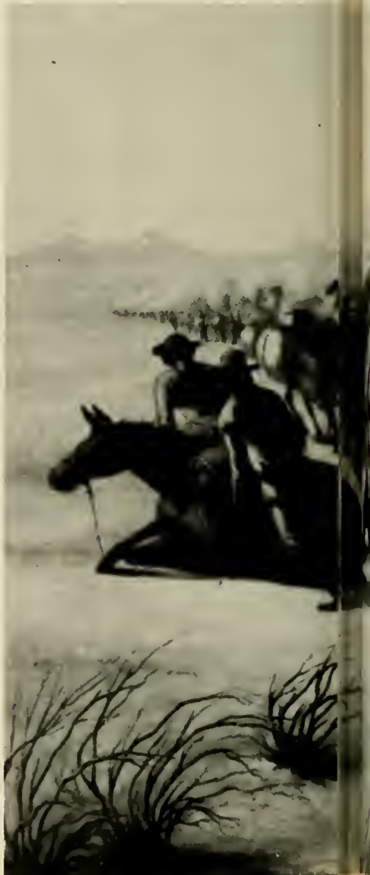
One officer, Maj. Henry Constantine Wayne, was especially enthusiastic about the concept. Wayne was a West Pointer who had been brevetted for gallantry at Contreras and Churubusco in the Mexican War. He proceeded to dig deeply into the subject of camels—the different breeds, their characteristics, economic usefulness, and thriftiness in Asia and Africa. He found that there were two distinct species: the one-humped, or Arabian, camel, *Camelus dromedarius*, poetically called the ship of the desert and used chiefly as a saddle animal; and the two-humped, or Bactrian, *Camelus bactrianus*, a heavier, slower-moving beast of burden. The dromedary was simply an Arabian camel of higher breeding, great speed, and endurance, but not a different animal, zoologically speaking.

Studying isothermal lines Major Wayne became convinced that climatic conditions in Texas, New Mexico, and California corresponded to the mean temperatures within the parallels of latitude limiting what he called Camel Land. It was beyond argument that in their native environment camels moved faster, endured longer, carried more freight, and required less water and forage than horses, mules, or oxen.

Working his way up through the military bureaucracy, Wayne made a formal recommendation to the War Department that the importation of camels should be undertaken to test the feasibility of camel cavalry. The idea reached Sen. Jefferson Davis, then chairman of the Senate Committee on Military Affairs. He liked it. And he knew, as a matter of history, that the French had used the dromedary with marked success in Egypt during the Napoleonic campaign and again in Algeria. Davis had commanded a regiment during the Mexican War and understood the problems of military and civilian communication in arid regions. He also wanted surveying and reconnaissance work done on an all-weather, transcontinental railroad route south of the Gila River (later the line of the Southern Pacific Railroad) that would close the vast gap between the civilization and commerce of the eastern states and the defenseless Pacific coast, and permit the South to share the economic advantages of the China trade and the development of the gold fields of California. The problem was acute, calling for imaginative new initiatives to make secure the onward march of empire.

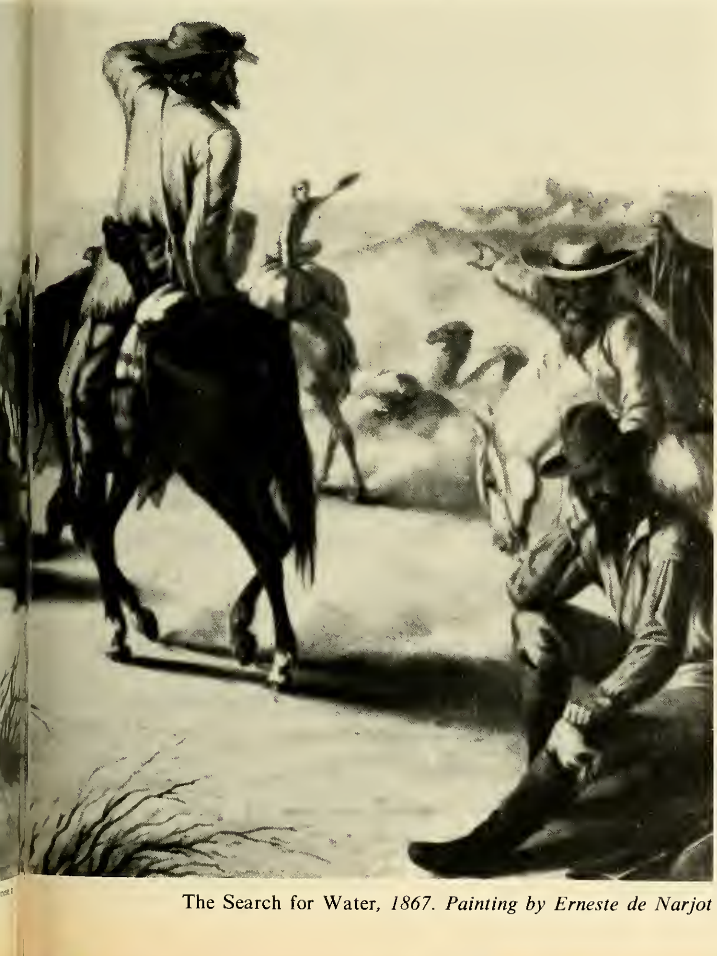
In 1851 Senator Davis tried to get an amendment to the army appropriation bill for the purchase of fifty camels and the hire of ten camel drivers, but objections were raised that the west was too cold for the animals, the expense too extravagant—the sum requested was $30,000—and a good deal of humor was expended upon the project in the Senate. A year later the House of Representatives, with support from the War Department, passed a camel bill but the Senate again rejected it.

Public support appeared in favor of the proposal. John Russell Bartlett, author and ethnologist, who had spent three years in the southwest as U. S. commissioner to run the boundary line between the United States and Mexico under the Treaty of Guadalupe Hi-



Photograph by Wm. Edmund Barrett. Courtesy of Decatur House, a property of the National Trust for Historic Preservation.

dalgo; archeologist George Robins Gliddon, who had lived in Egypt for twenty-three years and served there as vice-consul; and George Perkins Marsh, traveler, diplomat, and physiographer, who had lived in the Levant, all spoke up for the camel experiment. Marsh lectured on the subject at the Smithsonian Institution and wrote a book about it entitled *The Camel: His Organization, Habits, and Uses, Considered with Reference to His Introduction into the United States.*



The Search for Water, *1867. Painting by Erneste de Narjot*

A year later (1853) Jefferson Davis became Secretary of War in the administration of Pres. Franklin Pierce and strongly recommended the camel experiment to Congress but without success. In 1854, his annual report to the president again stressed the tenuous line of communication through Texas to the department of the Pacific and the large population of Indians in the region who were nomadic and predatory. "I again invite attention," Davis wrote,

> to the advantages to be anticipated from the use of camels and dromedaries for military and other purposes, and, for the reasons set forth in my last annual report, recommend that an appropriation be made to introduce a small number of the several varieties of this animal, to test their adaptation to our country.

In 1855, with support from western legislators and President Pierce, Davis at last secured the sum of $30,000 for camel purchases. The secretary moved quickly to procure the animals. The mission was placed in the hands of Major Wayne and Lt. David D. Porter of the Navy, who later achieved national fame for distinguished service during the Civil War.

As directed, in precise and meticulous orders from Secretary Davis, Wayne visited zoological gardens in England and France. In Paris, he also consulted with French officers who had had experience with camels in Algeria. Lieutenant Porter, in command of the storeship *Supply*, sailed to Italy; at Pisa he inspected camels owned by the duke of Tuscany, and reported that each camel could do the work of four horses. Wayne and Porter rendezvoused at Spezzia, then visited various ports in the eastern Mediterranean—Tunis, Smyrna, Salonika, and Constantinople. In a gesture of goodwill to the president and people of the United States, Mohammed Pasha, the bey of Tunis, gave the two officers a camel but it had to be unloaded at Alexandria because it developed an ailment called the itch, for which there was no cure. By this time Wayne and Porter had become expert camel traders and although many tried to defraud them, they could not be imposed upon. Past mistakes were liquidated; in one instance they sold a couple of unsuitable animals to a butcher at Constantinople, "who bought them," Porter said, "for purposes known only to himself."

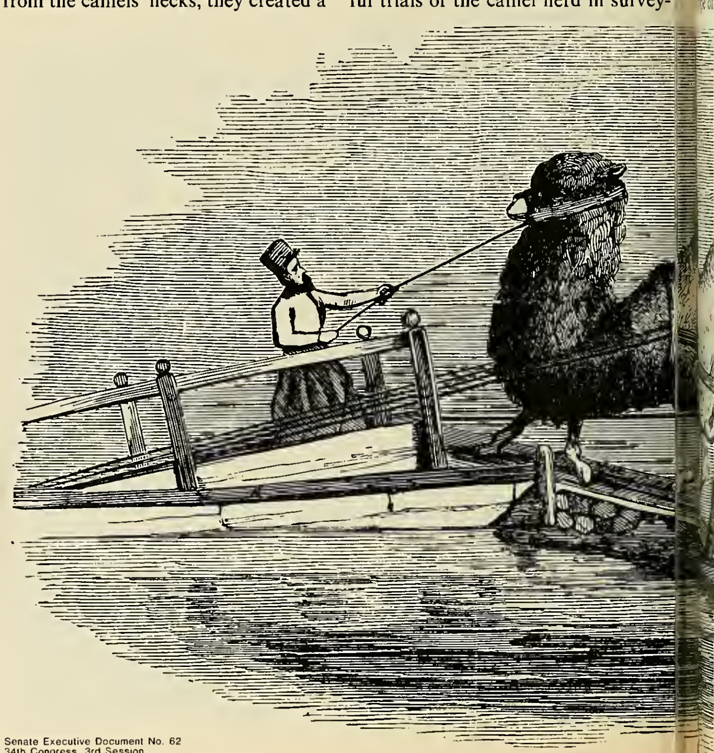
After a visit to Egypt the *Supply* sailed back to Smyrna to complete the cargo and on February 15, 1856, headed for the Texas gulf coast with nine swift dromedaries from Egypt, twenty burden camels, and four others of mixed breed. On the three-month return trip, the weather was often so rough that the beasts had to be strapped down on the camel deck to save them from injury. Wayne occupied himself in writing a long report to Secretary Davis and translating various works about camels from the French, while Porter kept a daily journal about the animals' health and their management aboard ship, recording in detail how they were rubbed, curried, oiled, and salted, also noting the birth of a baby camel at sea, which was named "Uncle Sam."

The ship dropped anchor in the Bay of Matagorda eight miles from Indianola, Texas, on the afternoon of April 29, 1856. The camels were in the care of native drivers, grouped together by the Americans under the generic name "Arabs," regardless of their ethnic mix. They had acquired anglicized names and nicknames, such as Greek George, Long Tom, Mico, and Hi-Jolly, which was Texan for Hadji Ali. Wearing red blankets, the animals were lightered to the wharf at Powder Point, three miles below Indianola. The camels, touching solid earth after their long confinement, reared, kicked, cried out, and broke halters, while the inhabitants of Indianola and Powder Point happily concluded that a free circus had come to town. Porter speculated that camel fighting might recommend his ungainly charges to the indigenous sporting population.

The *Supply* promptly undertook a second voyage, and early in 1857, forty-four camels were landed at the mouth of the Mississippi River. A third load was delivered at Indianola by private interests as a cover for the importation of slaves. These camels, having served their purpose, were turned loose to range the coastal country and were killed off by cattlemen. Meanwhile, Wayne had tested the camels' usefulness. A strong male loaded with 1,256 pounds of hay rose easily and walked off with the burden. Trips to San Antonio for supplies demonstrated that six camels could move as much freight as twelve horses in half the time, traverse muddy roads on which horses could not pull wagons, and climb mountain trails where no wheeled vehicle could roll.

The animals proved to be docile, except in the rutting season, but the army hostlers and wagon masters didn't like them and the camels' smell terrified the horses. Nevertheless, when the native drivers, in their colorful red coats and blue pants, rode into Houston, signaling their approach by the jingling of large bells suspended from the camels' necks, they created a sensation. People watched entranced as the camel drivers switched a camel's legs and the obedient beast kneeled and rose at the word of command. A Texas newspaper poet wrote in celebration of the exotic visitors in the columns of the *Indianola Bulletin* and a Miss Mary A. Shirkey of Victoria knitted a rather smelly pair of socks for President Pierce from the pile of a government camel. For this courtesy she received appropriate thanks, and Major Wayne thought that perhaps camel hair would be a spinoff from the experiment that would have economic value. Secretary Davis, in his final report at the end of 1856, assured the president that the effectiveness of camels in the American West had been established.

John B. Floyd, who succeeded Jefferson Davis at the War Department, shared his predecessor's views on the adaptability of the ship of the desert to conditions on the plains, mountains, and deserts of the southwest. But he was not able to persuade Congress in 1859, or again in 1860, to increase the American equity in camels. Meanwhile other officers had made successful trials of the camel herd in survey-



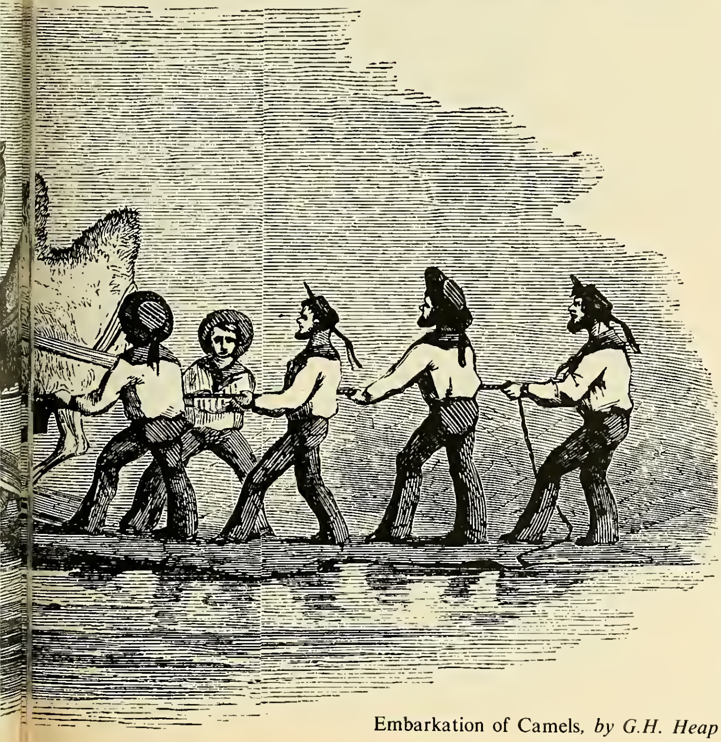
Senate Executive Document No. 62
34th Congress, 3rd Session

ing parties. Lt. Edward F. Beale in 1857 had thoroughly tested a portion of the camel herd while laying out the Great Wagon Road through Indian country. This expedition surveyed the route from Fort Defiance in New Mexico to the Colorado River or state line of California, near the thirty-fifth parallel.

The lieutenant was the only man in the party who liked and understood camels. There had been a contretemps involving the native drivers who had come to America with the animals. The drivers had refused to budge from their headquarters at San Antonio, "alleging that they had been badly treated by the government," Beale wrote in his journal, "not having received the pay due them since January . . . the appropriation having been exhausted, no one is authorized to pay them," although they "have performed their duties very faithfully." Beale had a good eye for the natural beauty of the landscape they passed through and for a picturesque scene. The camels, led by old Mahomet, stretched out in a "long line of . . . grave and patient followers"; as they wound down the slope of a bluff they made "a picture worthy of the pen of a great artist."

Beale found that it was indeed true that the camels could go without water for two days or more without difficulty and noted that, ironically, it was their task to carry breakers of water to sustain the horses and mules. As for forage, they actually preferred bitter herbs and dry shrubs such as greasewood, the low-growing brush prevalent in dry valleys, or the screw bean, a form of mesquite, to the finest grama grass. To the Oriental ruminants, the prickly pear, spiny mesquite, even the maguey with its tough blades and sharp needles were consumed with relish as "camel clover."

According to Alex E. Sweet and J. Armoy Knox, two adventurous newspapermen, sharp observers with a sense of humor, the camel was a voracious feeder, with a strong preference for cactus leaves and mesquite pods, "but he does not confine himself altogether to a vegetable diet. When opportunity offers, he will reach up after the glass insulators of a lightning-rod or telegraph pole, and conceal them in his commissary, or he will stand by the hour meekly chewing up a wagon-sheet, when he cannot get a chance to eat the well-rope or a wheelbarrow."



Embarkation of Camels, *by G.H. Heap*

At the beginning of the Civil War the government camels were kept in a camel pen with sixteen-foot walls of stone, concrete, adobe, and timber, at Val Verde. This military post, sixty miles southwest of San Antonio near the headwaters of a tributary of the Guadalupe River and three miles from Bandera Pass, was the permanent station of the Texas camels. Lieutenant Beale's camels remained in California, unused. An attempt was made to employ the beasts in carrying the mail, but post office officials, ignorant of the management of camels and not inclined to learn, successfully resisted the plan. During the war the California herd was sold to an entrepreneur who found buyers in circuses and zoological gardens.

In 1861 the Confederate forces seized the camels at Val Verde but the southern government was too overextended by the war to carry the experiment forward with vigor. The Confederate post office department used some of the camels; other animals carried cotton, a bale swung on each side, moving the cotton to Matamoras and returning with salt from Salt Lakes. Still others were turned loose and became wanderers. No particular care was taken to prevent their escape and they came to be regarded as a nuisance. Three were caught in Arkansas by Union soldiers. Another strayed west through Bandera Pass. When the camels were repossessed by the United States, the War Department no longer had the resources for carrying on the camel experiment. The railroads were coming and the whole idea of camels suffered from its close association with Jefferson Davis, officially a traitor for becoming the Confederate president. (Davis's citizenship was restored only two years ago, in 1978, when President Carter signed the necessary legislation.)

During the Reconstruction years the animals at the Val Verde station were scattered. Some ended up in the Ringling Brothers circus and camel driver Long Tom went with them. The government turned others loose in Arizona where they thrived and multiplied. In 1870 a Nevada salt miner rounded up twenty-five in the Carson River district. The camels must have been numerous and troublesome in Nevada because the state legislature passed a law in 1875 making it a misdemeanor for the owner of "any camel or camels, dromedary or dromedaries

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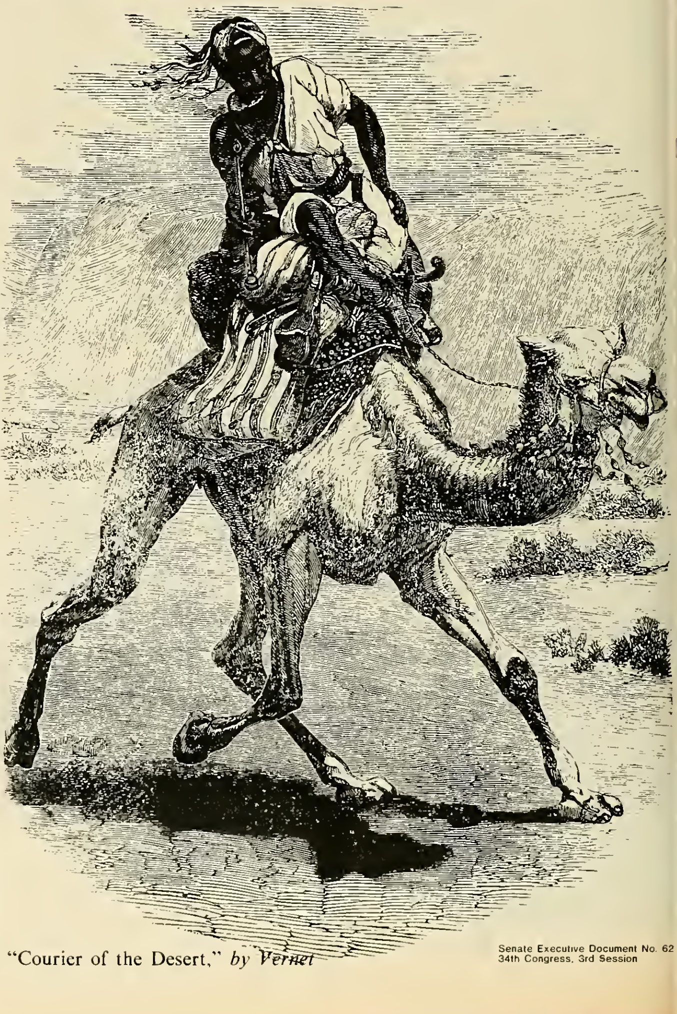
Sightings of government camels and their descendants continued for the rest of the nineteenth century. They were seen ranging with cattle, and often a lumbering old beast showed up at a roundup. One came out of a mesquite bush at Refugio at milking time, a grotesque figure. "The cow," Chris Emmet wrote in *Texas Camel Tales*, "departed without ceremony." A herd was seen near Oatman's Flat on the Gila River in 1875. A decade later a little boy of five whose father was commander of the army garrison at Fort Selden, New Mexico, saw an extraordinary sight that he recollected later in life. "One day a curious and frightening animal with a blobbish head, long and curving neck, and shambling legs, moseyed out of the Jornada [Jornada del Muerto] . . . the animal was . . . one of the old army camels." The little boy was Gen. Douglas MacArthur.

In 1890, or maybe it was 1891, nine camels roaming on the western edge of Death Valley, California, appeared, silhouetted against the sky, before the eyes of two gold miners who thought they were seeing ghosts. The miners, Shep Searcy and Charlie Fisher, were lying down at the time, trying to drink from a mud puddle, when Shep said, "Do you see what I see?"

Fisher answered, "I do not know what you see, Shep, but it looks like Barnum's circus to me."



"Courier of the Desert," *by Vernet*

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Then the camels sniffed, snorted, and ran away. When the miners reported their experience at the next town, people thought they were crazy.

"The attempt to make use of camels might have succeeded under different conditions," wrote the late Walter L. Fleming, dean of Vanderbilt University and an authority on the experiment in all of its ramifications. The operation lost its strongest advocate when Jefferson Davis left the War Department. Major Wayne, the camels' best friend, who had both theoretical and practical knowledge of the animals, had joined the Confederate army in 1860. Beale, who once drove a hundred miles in a sulky drawn by a team of camels with whom he carried on a conversation in Syrian, was discouraged by officialdom from pursuing his experiments. Finally the rapid expansion of the rail network made transportation by beasts of burden a picturesque but historical anachronism.

Thus endeth a story of the American West, filled with desert dust and camel musk. The camel drivers, strangers in a strange land, lost in the alien culture of the Anglo-Americans, deserve a last word. Greek George, a sturdy man with a Homeric beard, became George Allen and died an old man in Whittier, California, September 2, 1915. Long Tom went with the Ringling Brothers circus, as mentioned earlier. Hi-Jolly wandered for decades over the desert as a prospector and was reported to have died in Arizona in 1902. But J.W. Walker, who had herded camels at Val Verde, told a different story. He said that some fellows saw an old camel browsing near a town where they had gone "to get 'wet up' a little" at a saloon. Standing at the bar they told of seeing the camel. A dark-skinned man standing near them asked quietly, "Boys, where is that old camel?" After they told him, he pulled his hat down hard and walked off in the direction that they indicated. The next day, cowmen hunting strays found Hi-Jolly and the camel lying dead. Hi-Jolly's arms were around the animal's neck.

"I don't suppose this story is true," Walker recalled, "but that's the way I'm always going to believe old Hi-Jolly died."

*Gerald Carson is author of the book* Men, Beasts and Gods: A History of Cruelty and Kindness to Animals *(Scribner paperback).*

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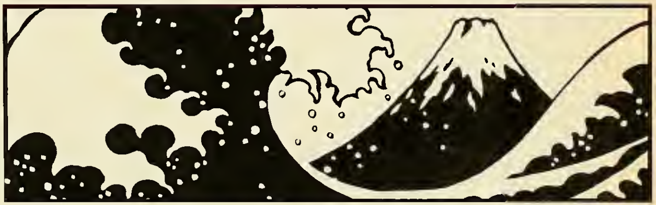

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# Celestial Events

by Thomas D. Nicholson

**Sun and Moon** Since the moon was full on the last day of April, it becomes a morning object on May 1, waning in phase, rising after dark, and remaining in the sky past dawn. Last-quarter is on May 7, new moon on the 14th. It becomes an evening object again when the young crescent appears at sundown on the 16th or 17th, reaching first-quarter on the 21st and full on the 29th. Phases in June are: last-quarter on the 5th, new moon on the 12th, first-quarter on the 20th, full on the 28th. Perigee moon (nearest the earth) is on May 12, June 4, and June 30; apogee moon (farthest from the earth) is on May 21 and June 18.

**Stars and Planets** Bright planets continue to dominate the evening sky: Venus in the west; Jupiter, Mars, and Saturn (and the nearby bright star Regulus) in the east. But an experienced observer will see signs that they are past their prime. Venus is high and bright at sundown, better than it has been all year. After mid-May, however, it will be noticeably lower and will set earlier on each successive night. Its brightness will begin to fade toward the end of May. Jupiter, Mars, and Saturn are conspicuous in Leo, along with Regulus, its brightest star. They will be well up in the south at dusk, setting in the west a few hours past midnight. Jupiter and Mars are very close to Regulus in early May, and Mars is still quite bright. They will present an impressive gathering of bright objects. But the configuration decays after midmonth as Mars moves swiftly away to the east (left) and dims. Mercury moves from Pisces, through Aries and Taurus, into Gemini; Venus drifts from Taurus into Gemini before mid-May; Jupiter, Mars, and Saturn remain in Leo, Uranus in Libra, Neptune in Ophiuchus, and Pluto in Bootes.

May 4: Mars and Jupiter are in conjunction. Mars now moves from west to east (right to left) past Jupiter. The Eta Aquarid meteor shower (20 meteors per hour) reaches maximum.

May 8: Venus is at greatest brilliancy in the evening sky.

May 13: Mercury, in superior conjunction, becomes an evening star.

May 15: The moon occults (covers) Aldebaran over North America at about 9:00 A.M., EST.

May 16: The moon is near Venus tonight.

May 21–23: The moon offers an exceptional opportunity to identify Regulus, Jupiter, Mars, and Saturn as it moves past each in turn.

May 23: Saturn resumes its direct (easterly) motion.

May 24: Venus begins its retrograde (westerly) motion.

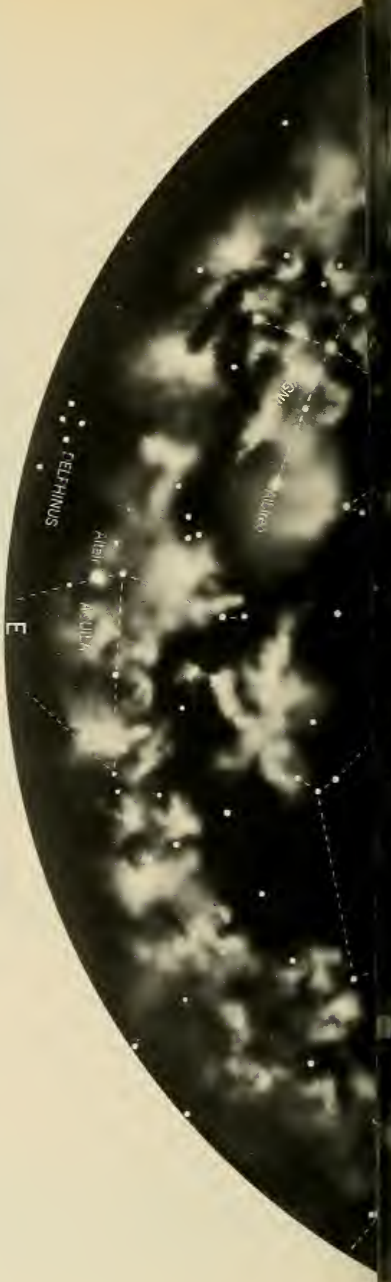
May 31–June 1: Mercury and Venus are in conjunction at 1:00 P.M., EST, on both evenings. Mercury will appear as a bright object very close to Venus.

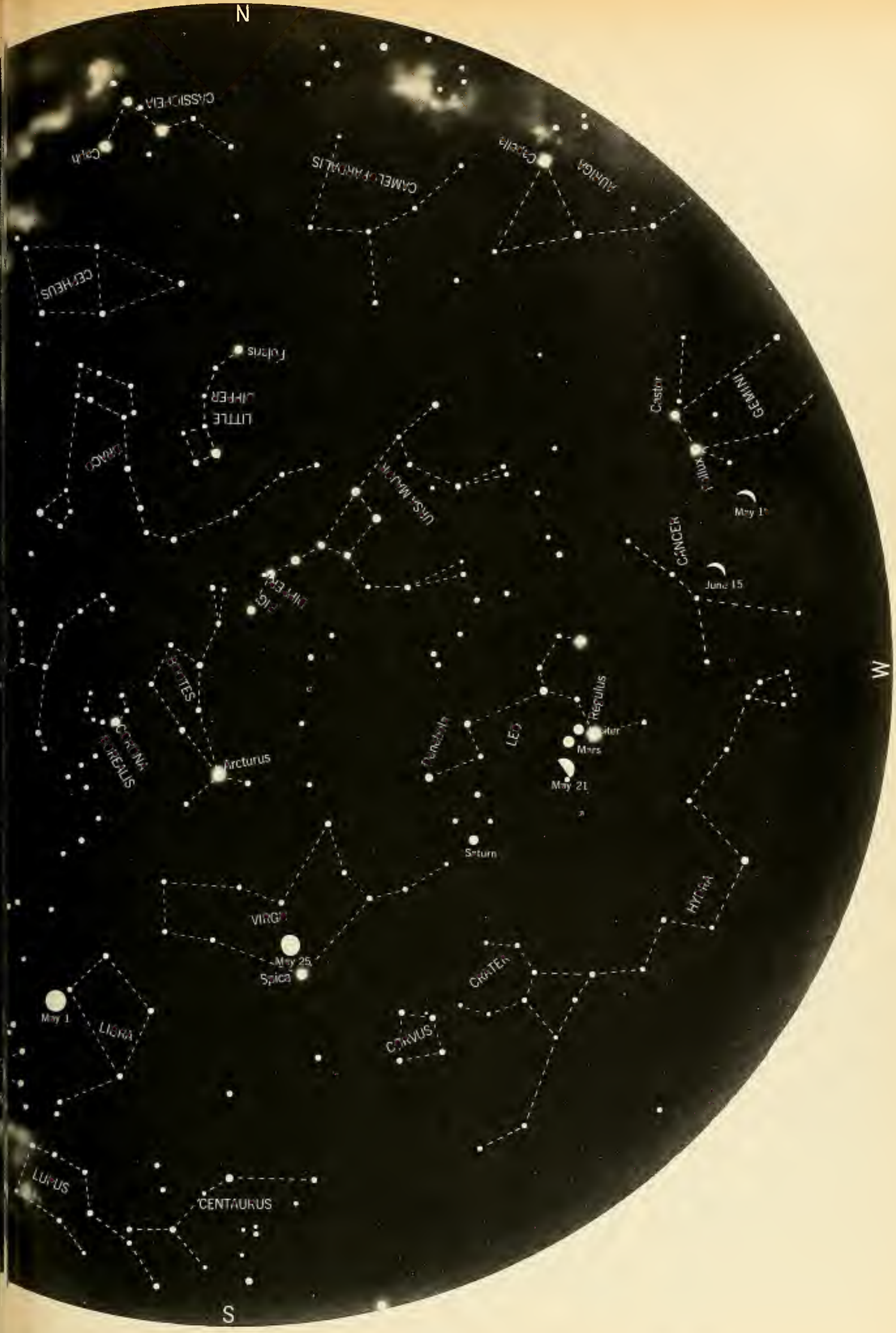
June 11: The moon occults Aldebaran over North America at about 7:00 P.M., EST.

June 14: Mercury, at greatest easterly elongation, is well placed as an evening star.

June 15: Venus, in inferior conjunction, becomes a morning star.

**Evening Star Map** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those in the sky. When you face the other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match the stars in the sky with those on the lower half of the map. The map represents the sky at about 11–12 P.M. on May 1; 10–11 P.M. on May 15; 9–10 P.M. on May 31; and 8–9 P.M. on June 15. It shows only planets and moon phases above the horizon at those times.

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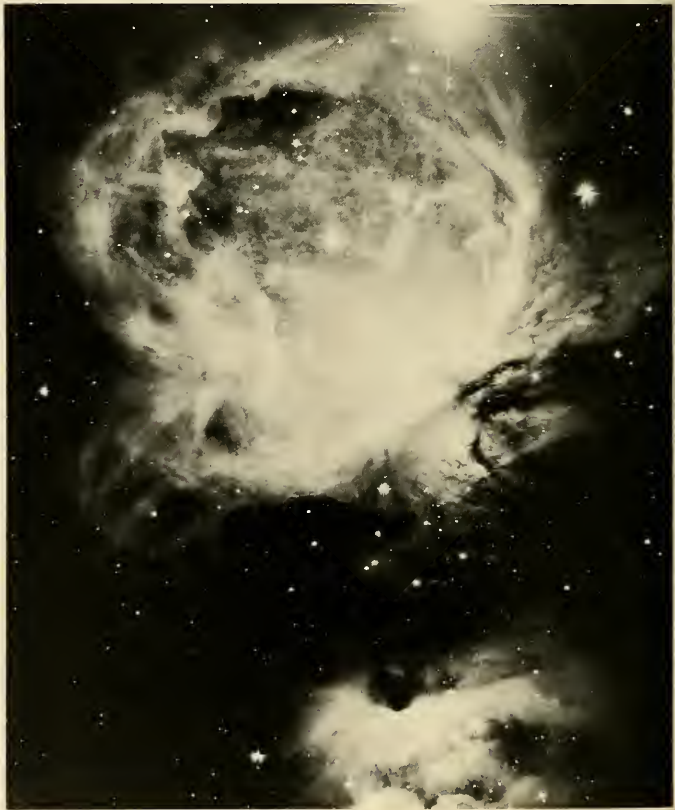
# The Orion Nebula

*Why is this well-known object expanding in only one direction?*

**by Stephen P. Maran**

Anyone who has leafed through an illustrated book on astronomy has seen a picture of the Great Nebula in Orion, also known as M42. The brightest and perhaps most spectacular nebula in the heavens, it is a cloud of hot, glowing gas. Located in Orion's Sword, M42 is about 1,500 light-years from the earth. Even when seen through an amateur astronomer's small telescope, the nebula is a superb sight. At its heart are four hot young stars, known as the Trapezium for their simple geometric pattern.

Orion itself is a striking constellation. It contains many bright stars and straddles the celestial equator, so it is at least partially visible from every spot on earth. Thus, it was natural for Galileo, in 1609, to turn his new tele-



*The Great Nebula in Orion*

Lick Observatory

scope in Orion's direction. He scanned the region around the Sword and found that diffuse patches of the Milky Way were telescopically resolved into a myriad of tiny stars. And yet the Great Nebula, which must have been plainly visible, is not mentioned in Galileo's notes. Instead it was a French lawyer and astronomy buff, Nicholas-Claude Fabri de Peiresc, who discovered the nebula in 1610 with one of Galileo's own telescopes.

Peiresc's discovery was apparently overlooked or forgotten, and a Swiss astronomer, Cysatus, "discovered" M42 anew in about the year 1618. His report was well preserved (although at least one famed seventeenth-century astronomer was unaware of it), and a cursory inspection suggests that most modern accounts credit Cysatus rather than Peiresc with finding the Orion Nebula.

The noted astronomer who was ignorant of even Cysatus's "discovery" was Christian Huygens, a Dutch optics expert and clockmaker. As late as 1656, he too reported "discovering" the Orion Nebula. Huygens compared it to "an opening in the sky through which a brighter region was visible." His drawing of the nebula and those of later astronomers who studied it differed greatly from each other, leading to the suspicion that M42's shape might have changed. But the differences in the sketches of the nebula were the result of artistic license taken by the observers, who were confronted with the difficult task of drawing a telescopically viewed object of amorphous appearance while working in the darkened surroundings of an observatory.

The designation "M42" comes from the serial number of the Orion Nebula in a catalog of nebulae and star clusters published by the French astronomer Messier in 1784. By the late eight-

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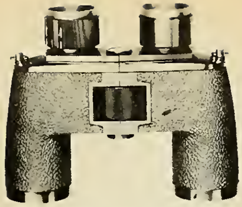

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eenth century, it was known that some of these "nebulae" had spiral-shaped features. Today we know that such objects are *not* gaseous nebulae like M42, but are spiral galaxies, island universes far larger and more distant than the Orion Nebula. However, this modern distinction had not been made when, in the 1780s (and on subsequent occasions well into the nineteenth century), much effort was spent in the attempt to discern spiral features in the Orion Nebula. Some astronomers did "find" spiral forms in the Great Nebula, just as some astronomers claimed to "see" canals on Mars. But in fact there are none.

By the 1950s, it was known that the Orion Nebula is an H II region, meaning a cloud of electrically charged, or ionized, hydrogen and other gases that are heated by ultraviolet radiation. That radiation also excites the gases electrically, causing them to glow.

Most of the radiation that excites the gases in the Orion Nebula comes from the hottest of the four Trapezium stars. Ultraviolet radiation streams out from this star equally in all directions, heating and exciting the surrounding gas. This simple explanation can be found in many texts, but the actual situation is more complex.

Since a hot, unconfined gas will expand, the above simple theory would lead us to expect that the hot gas of the Orion Nebula is flowing outward. Such is the case on the side of the nebula that faces the earth, as shown by the presence of blue-shifted emission lines in the spectrum of the nebula. These shifts, caused by the Doppler effect, indicate that gas is indeed streaming toward us. By the same token, the gas on the far side of the nebula should be moving away from us and hence should produce red-shifted spectral lines. But lines of the latter type are not present.

There is known to be some interstellar dust (microscopic rock particles) in the Orion Nebula. This finding suggested the following explanation for the lack of red-shifted lines from the far side of M42: there might be more dust in the far half of the nebula than in the near half, dimming the light from the far side and making the postulated red-shifted lines invisible from the earth. This explanation, however, has been ruled out by observations with a radiotelescope.

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line of hydrogen, made in the 1960s, thus were capable of surveying the entire Orion Nebula, whether or not there is much dust in its far half. Nevertheless, those measurements failed to turn up the anticipated red-shifted emission. Instead, they revealed the same pattern of motion in the nebula that had already been found in the visible-light spectrum: the gas was expanding toward the earth, but not away. This is not just a simple case of the nebula as a whole moving toward us (as opposed to its expanding in size), for in that case we would observe identical blue shifts at all positions on it. The nebula really *is* expanding, but only in one direction.

The gaseous outward flow of the Orion Nebula is not uniform and some of the nebular gas does not even participate measurably in the flow. An important clue to the conditions of the flow came in a 1966 study by James B. Kaler, an expert on nebulae at the University of Illinois Observatory in Champaign-Urbana. He examined the radial velocity, that is, the motion along the line of sight from the earth, as revealed by Doppler shifts, of seven types of ions in the Orion Nebula. (An ion is an electrically charged atom that has lost one or more of its electrons; in the case of this nebula, as a result of exposure to ultraviolet radiation.)

Kaler discovered that although the velocities of the various ions in the Orion Nebula differ greatly, they differ in a systematic way. The cooler ions are moving at about the same speed as the Trapezium stars. In effect, these ions constitute a gas that is nearly at rest with respect to the center of the nebula. This does not mean that the cool gas is at the center; being closest to the hot, radiating stars, the center should be hottest. However, Kaler found that the hottest ions are moving rapidly toward the earth.

If the Orion Nebula is expanding toward us but not away, then something must be confining the rear hemisphere of the nebula. The discovery of radio emission from formaldehyde and other complex molecules in the direction of the nebula, made during the early 1970s, revealed what the obstacle must be. These molecules can only exist in a very cool gas, shrouded from disruptive ultraviolet light by thick dust. The radio observations indicated that a large dark cloud, more massive, denser, colder, and dustier than the Orion Nebula, lies just behind it. The thin expanding gases of the nebula cannot penetrate the denser medium of that molecular cloud. Hence they do not flow toward it but only toward us.

Infrared telescopes reveal that new stars are forming behind the Orion Nebula, in the thick gas and dust of the Orion molecular cloud. As the new stars evolve, their surface temperatures will increase and they will emit large amounts of visible and ultraviolet light. This radiation will evaporate some of the dust around them and will heat and ionize the gas in their vicinity, causing it to glow. The process, astronomers now believe, has already taken place in the Orion Nebula; the Trapezium stars that formed at the edge of the dark cloud behind the nebula have heated their surroundings to form a glowing region, or "blister" in the jargon of astrophysics, around them. The blister is the Orion Nebula and its expanding gases flow toward us; at its rear, the warm blister is slowly eating away at the boundary of the mother cloud, warming the adjacent cool material in the manner of a spreading infection.

The freshly warmed material at the back boundary of the Orion Nebula probably corresponds to the cooler gas found by Kaler that is not perceptibly expanding. As that material is exposed to more ultraviolet light and is heated further, it joins the rapid flow away from the dense cloud, like steam issuing from a kettle. A few isolated clumps of dark material do exist on the near-side boundary of the Orion Nebula. The gas at the rear of these clumps faces the Trapezium and hence is slowly warming up. As it warms, it expands away from the dark clumps and thus flows *toward* the Trapezium and away from the earth. This limited flow away from us and toward the center of the Orion Nebula is an exception that confirms our understanding of what is happening in the nebula and why.

The astronomers of earlier times could only explore the Orion Nebula in visible light; nevertheless, they found it an impressive object. Radio and infrared telescopes now verify that a previously unsuspected dark molecular cloud is actually the principal object in the Sword of Orion and the parent body of the Great Nebula itself.

*Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.*

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# After Audubon

**by Peter Farb**

On the Road with John James Audubon, by Mary Durant and Michael Harwood. *Dodd, Mead and Company, $19.95; 576 pp., illus.*

Following in the footsteps of a noted traveler—reconstructing a lost world and illuminating it with modern scientific knowledge—is an inherently fascinating genre that in recent years has resulted in books retracing the paths of Homer, Saint Paul, Darwin, and others, yet it has produced no very memorable book—until this one. Durant and Harwood have given us an eminently readable, endlessly fascinating journal that retraces Audubon's comings and goings from his arrival in the United States in 1803 to his death in northern Manhattan Island in 1843. They have achieved this partly because they have combined the "in-the-footsteps-of" genre with another that is best exemplified by Roger Tory Peterson and James Fisher's *Wild America* (1955). This second type gives the follower of footsteps a partner, with the result that two knowledgeable travelers can compare notes, offer different points of view, and in general enliven the inevitable dull stretches of the journey. Durant and Harwood are invariably informative, enthusiastic, and cheerful. They have done their homework in reading all of Audubon's writings and many works about the American land, they know their ecology and natural history, and they are sensitive observers of human life as well.

The pattern of the book is first, to offer for each place a brief quotation from Audubon's writings, then follow with a modern description, additional facts, interpretation, a dialogue between the authors, and sometimes their dispute with Audubon. This pattern is invariable and might have become boring in such a long book, but it gains flexibility through the liveliness of the writing, the freshness of the authors' impressions, and the occasional badinage between them. Potential dull spots are enlivened with humor, as when Durant and Harwood become impatient with the precious bird names given streets in Louisville, Kentucky, and compete in making up some of their own: Rue Cuckoo, Rail Road, Tern Pike. The writing is often imaginative, as in this description of the mockingbird: "The mocker's song puts Michael in mind of Latin declensions. It speaks to me of embroidery stitches. The song is like a sampler—rows of elaborate stitches, no two rows alike, and each row sewn in bright silk flosses with a gold needle."

To write their book, Durant and Harwood compressed Audubon's four decades of travel into a little more than a year of their own traveling. They logged some 35,000 miles—by automobile, Mississippi River towboat, cutter, ferry, and their own legs—from Labrador to the Dry Tortugas off southern Florida and west to Montana and Texas (Audubon never accomplished his desire to cross the Rockies to the West Coast). They explored the rivers and creeks, bayous, shores, forests, and prairies that Audubon had known, and also the once-wild lands that are now the slums of large cities.

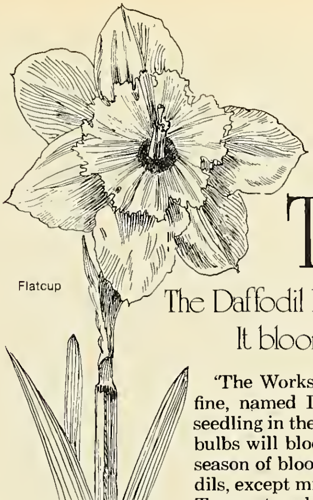
As this issue went to press, *Natural History* was saddened to learn of the death of Peter Farb on April 8, 1980.

Their travels began in Mill Grove, Pennsylvania, where Audubon had arrived in 1803, age eighteen, the illegit-

# Books in Review

United States to escape conscription into the French army. From there they inquire into Audubon's early mercantile businesses in Louisville and Henderson, Kentucky, search out descendants of Audubon's storekeeping partner in Saint Genevieve, Missouri, trace his route down the Mississippi to Saint Francisville, Louisiana (where Audubon was to stay for eight years), following him even when he was himself retracing the footsteps of Alexander Wilson, then on to South Carolina and Florida, northward to Canada, to the Missouri River—in short, searching out virtually every place, even those seemingly of little consequence, that Audubon mentioned in his extensive writings.

It is all here, almost every move Audubon made, down to the completion of the *Birds of America*—called by his contemporary Baron Cuvier "the most important monument which has been erected by Art to Nature"—and the near completion of the *Viviparous Quadrupeds of North America.* The story ends with Audubon's death, the subsequent impoverishment and hard luck of his family, the rats devouring the unsold copies of the *Ornithological Biography*, the copper plates of the bird engravings sold as scrap metal, and the sale of the original paintings for a mere $2,000 to the New York Historical Society (which did not fully exhibit them until this past decade). The authors' journey is arduous, but we rarely grow weary accompanying them, in large part because they manage at every stop to evoke the time past, to supply us with interesting facts, and to guide us through the many inconsistencies in Audubon's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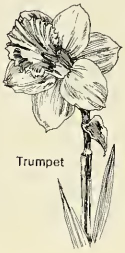
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work. They provide, for example, a very helpful key to the fanciful names Audubon often gave various birds—such as Brown Eagle (he probably meant both the immature bald eagle and the adult golden), Dun Diver (the female common merganser), French Mocking Bird (brown thrasher), and Irish Goose (double-crested cormorant).

So much research and traveling hither and yon on the part of the authors would hardly have been worth the trouble were Audubon not a complex and interesting personality. Everyone knows of the prodigies he performed for conservation and his pioneering efforts in systematically studying the fauna of a continent. But not generally advertised by the local, state, and national Audubon societies that have taken his name are his less praiseworthy traits: he was a habitual liar (he claimed, to mention just one fabrication, to have studied with the great French artist Jacques Louis David), a plagiarist (a shameless pirate of bird illustrations by others), a poseur (on a sales trip to England, he smeared his hair with bear grease and dressed up in frontier costumes he never wore in America), a butcher (he blasted for sport many more birds than he needed for copying or for food), and an irresponsible family man (leaving wife and brood to fend for themselves).

I have always considered particularly distasteful Audubon's opportunism regarding native Americans, and I am glad that the authors do not gloss over these facts. The Audubon who had expressed sorrow at the plight of the Seminoles, the forced relocation of the Cherokees, the rapid disappearance of the Indians of Labrador made a complete reversal after being taken to task as an Indian lover. He was soon to label the Indians "savages," even blaming them for dying in such great numbers from the white man's smallpox. Nor do the authors avoid pointing out that he was a dandy, a salesman, a merchant who developed his passion for natural history only when his life was considerably more than half over. They are skeptical where skepticism is needed, as when they give the lie to some of Audubon's outrageous claims; they touch on Audubon's shabby treatment of Alexander Wilson; they deplore his gulling of the naturalist Constantine Rafinesque with fanciful descriptions of birds and fishes, which, published in scientific journals, must have set American natural history

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back a decade. The outrageous myths Audubon created to hide his bastardy are also discussed: he invented a birthplace for himself in a Louisiana mansion (instead of the actual trader's house on the island of Santo Domingo), an aristocratic Spanish mother (instead of the real French chambermaid), and he even confided to his family and close friends that he was really the Lost Dauphin, that missing offspring of Louis XVI and Marie Antoinette.

As husband and wife, Durant and Harwood are interested in the relations between Audubon and his extraordinarily indulgent wife, Lucy. Early in the book, Mary Durant puts under scrutiny a seemingly enthusiastic letter by Lucy about Louisville, the first place to which she accompanied Audubon when he left Mill Grove to become a storekeeper. Lucy praises the gardens, the welcome given them by the inhabitants, and the privacy they enjoy. Michael Harwood takes Lucy at her word, but Mary Durant reads "negatives, spoken and unspoken, in every line." Durant points out that Louisville was then known as the Graveyard of the Ohio because of the prevalence of diseases, its main street was known as the Slough of Despond because of the muddy hog pens and wastes from slaughterhouses, and the neighbors who allowed them privacy were prostitutes, gamblers, and drunkards. Later in the book, Durant recalls Lucy's often quoted statement, "I have a rival in every bird"—but believes that things were much more complex than that. Durant and Harwood speculate about Lucy's reactions to her vain, impudent, braggart husband who made foolish investments in his hope to get rich quick. They suggest that Audubon may not have remained celibate on his travels, for he alludes to his flirtations and to the pleasures of what he calls "horizontal patterns." About halfway through the book, Durant decides that she is not fond of Lucy: "I get the strong impression that she was among those self-righteous people who never let you forget just how noble they have been."

I have dwelt on the less pleasant aspects of Audubon's life not because this is a muckraking book or a psychobiography but rather to impress on you that this book is much more than a litany of places and sights and that the authors, while mindful of the contributions of Audubon, do not worship blindly. By the end of the book, following the footsteps of Audubon has become for Durant and Harwood not just an exploration into the heart of a continent but also a journey into the heart of Audubon. Concludes Mary Durant:

> I realize for the first time that I know more about John James Audubon than I do about anyone else in the world, except myself. . . . I've read his journals, his mail, his anecdotes, his essays. We've stood in his tracks, tramped his woods and marshes, his riverbanks and seashores, climbed his hills, seen his vistas, slept under his skies and his moon. We have followed him down the arches of the years, and this moment, at his gravesite, is the day of his death.

Mary Durant writes that her eyes then fill with tears—and such trusted companions have the authors become that we don't find anything sentimental about it at all.

*Peter Farb's newest book,* Consuming Passions; The Anthropology of Eating, *will be published in September by Houghton Mifflin.*

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# Additional Reading

**Mackinac Island** (p. 34)

*Silent Spring*, by Rachel Carson (New York: Fawcett World Library, 1978), is a compelling introduction to the many ways humankind has altered and damaged the environment through the use of chemicals. Robert van den Bosch's article "The Melancholy Addiction of Ol' King Cotton" (*Natural History*, December 1971, pp. 86–91) discusses the disastrous effects of the heavy use of insecticides to control insect predation on the cotton plant. In *The Pesticide Conspiracy* (New York: Doubleday and Co., 1978), van den Bosch further explains how pesticides kill more than pests and how insects adapt to poisons. R. L. Rudd discusses pesticides in the food chain and the fate of pesticides in the environment in *Pesticides and the Living Landscape* (Madison: University of Wisconsin Press, 1964). "The Unforeseen International Ecologic Boomerang," edited by Taghi Farvar and John Milton (*Natural History*, February 1969, pp. 41–72), presents reports on the effects new technologies have had on the environments of underdeveloped countries. "Natural Decline of a Pine Needle Scale (*Chionaspis pinifoliae [Fitch]*), Outbreak at South Lake Tahoe, California, Following Cessation of Adult Mosquito Control with Malathion," by R. F. Luck and D. L. Dahlsten (*Ecology*, vol. 56, pp. 893–904), is a specific account of the disruption of the balance of nature by a pesticide. *The Theory and Practice of Biological Control*, edited by C.B. Huffaker and P.S. Messenger (New York: Academic Press, 1977), proposes economically and ecologically sound systems of pest control and discusses the philosophy, theory, basic biology, and ecology of conventional biological control. An older collection of articles on insect problems in agriculture is *Introduction to Insect Pest Management*, edited by Robert L. Metcalf and William Luckmann (New York: J. Wiley and Sons, 1975). *Biological Control by Natural Enemies*, by Paul Debach (New York: Cambridge University Press, 1974), is an undergraduate-level text. A soon-to-be-revised edition of *Perspectives in Urban Entomology*, edited by G. W. Frankie and C. S. Koehler (New York: Academic Press, 1978), one of the first books to examine the urban pest problem, will focus more on the social implications of urban entomology and will have further reports by Richard Merritt and Keith Kennedy on the Mackinac Island fly problem.

**Illinois River Turtles** (p. 42)

*Turtles of the United States*, by C.H. Ernst and R.W. Barbour (Lexington: University Press of Kentucky, 1972), generally treats life histories of United States turtles. An older account, covering seventy-nine species and subspecies, is Archie Carr's *Handbook of Turtles: The Turtles of the United States, Canada, and Baja California* (Ithaca: Cornell University Press, 1952). *Turtles: Perspectives and Research*, edited by Marion Harless and Henry Morlock (New York: J. Wiley and Sons, 1979), is a compilation of data from the most recent turtle research. *Turtles of the World*, by Peter Pritchard (Neptune: T.F.H. Publications, 1966), is a reference used by herpetologists. *River Ecology and Man*, edited by Ray T. Oglesby, Clarence A. Carlson, and James A. McCann (New York: Academic Press, 1972), includes the chapter "Man and the Illinois River," by W. C. Starrett. More specific information can be found in *Man's Effect on the Fish and Wildlife of the Illinois River*, by H. B. Mills, W. C. Starrett, and F. C. Bellrose (Urbana: Illinois Natural History Survey Biological Notes, no. 57), and *Amphibians and Reptiles of Illinois*, by Philip W. Smith (Illinois Natural History Survey Bulletin, vol. 28, art. 1).

**Bowhead Whales** (p. 52)

Not much has been published on Eskimo whaling. *Alaska Whales and Whaling*, a colorful issue of *Alaska Geographic* (vol. 5, no. 4, 1978), includes articles on "Early Native Whaling in Alaska" and "Modern Eskimo Whaling," along with others on kinds of whales, whale distribution, and the history of whaling. More on the history of whaling can be found in John R. Bockstoce's *Steam Whaling in the Western Arctic* (Seattle: University of Washington Press, 1978). *Thomas Welcome Roys: America's Pioneer of Modern Whaling* is a biography of the whaling captain whose steam-powered factory ship and winch-operated device to retrieve sunken whales greatly increased the whaler's ability to process the kill.This book, coauthored by Frederick P. Schmitt, Cornelis de Jong, and Frank H. Winter, will be published later this year by the University Press of Virginia. The conflict between cod fishermen and the endangered humpback whale is discussed in "The Humpback is Not Over the Hump," by Jon Lien and Bora Merdsoy, *Natural History*, June/July 1979. The "Additional Reading" column of that issue describes seven more whale references. For the story of the Eskimo walrus hunters of Little Diomede Island, see Fred Bruemmer's "Life on a Cold Rock" (*Natural History*, March 1977, pp. 54–65).

**Jupiter** (p. 62)

Two articles in *Science*, "Mission to Jupiter and Its Satellites" (June 1, 1979) and "Mission to Jupiter and Its Satellites: *Voyager 2*" (November 23, 1979), and the August 30, 1979, issue of *Nature*, entitled *Jupiter and Io: A Special Supplement*, offer a wealth of information on the *Voyager* missions. See the March, May, September, and October 1979 issues of *Astronomy* for many short, colorful articles on Jupiter and its moons. "Jupiter," by John H. Wolfe, appears with eleven other articles on the solar system in the September 1975 issue of *Scientific American*. In "The Meteorology of Jupiter" (*Scientific American*, March 1976, pp. 46–56), Andrew Ingersoll analyzes weather patterns on Jupiter as recorded by *Pioneer 10*. Isaac Asimov discusses early records of Jupiter and recent discoveries about atmosphere, composition, and the Great Red Spot in *Jupiter: The Largest Planet* (New York: Lothrop, Lee, and Shepard Co., 1976). *Moons and Planets: An Introduction to Planetary Science*, by William K. Hartmann (Belmont: Wadsworth Publishing Co., 1972), and Joseph Chamberlain's *Theory of Planetary Atmospheres: An Introduction to Their Physics and Chemistry* (Chicago: Academic Press, 1978) are college-level textbooks. A useful, al-

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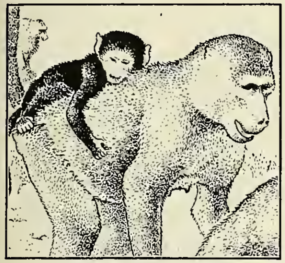

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though dated, technical reference is the comprehensive *Jupiter: Studies of the Interior, Atmosphere, Magnetosphere, and Satellites*, edited by T. Gehrels (Tucson: University of Arizona Press, 1976). Jupiter's moons are featured in "What *Voyager* Saw: Jupiter's Dazzling Realm," by Rick Gore (*National Geographic*, January 1980, pp. 2–29). The 1979 edition of Robert Jastrow's *Red Giants and White Dwarfs* (New York: W. W. Norton), a general history of the universe, includes color photographs of Jupiter and its moons taken from *Voyager*. Starting in October 1980, the Public Broadcasting Service will present "Cosmos," a thirteen-part television series, written and narrated by Carl Sagan. The executive producer is Adrian Malone ("Ascent of Man," "Age of Uncertainty"), and episode six will be devoted to the *Voyager 1* and *2* missions to Jupiter and beyond.

**Camels** (p. 70)

Much of the information on the U.S. government's camel experiment is buried in monographs and official publications. Some data are scattered throughout books that may be more accessible than government publications. For books on Jefferson Davis, see the AMS Press reprint of *Jefferson Davis, Constitutionalist: His Letters, Papers and Speeches,* volume 2, edited by Dunbar Rowland and first published in 1923, and *Jefferson Davis: American Patriot 1808–1861*, volume 1, by Hudson Strode (New York: Harcourt, Brace and Co., 1955). Both volumes of Robert McElroy's *Jefferson Davis: The Unreal and the Real* (New York: Harper and Bros., 1937) were reprinted by Kraus Reprints (Millwood, 1969). Information on the United States camels can be found in Chris Emmett's *Texas Camel Tales* (Austin: Steck-Vaughn Co., 1932, repr. 1969) and in Lewis Burt Lesley's *Uncle Sam's Camels: The Journal of May Humphreys Stacey Supplemented by the Report of Edward Fitzgerald Beale (1857–1858)*, published by Harvard University Press, 1929. Jefferson Davis's own account of the experiment appeared in his 1857 *Report of the Secretary of War, Communicating, in Compliance with a Resolution of the Senate of February 2, 1857, Information Respecting the Purchase of Camels for the Purposes of Military Transportation* (Sen. Ex. Doc. No. 62).

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# Skin and Bones

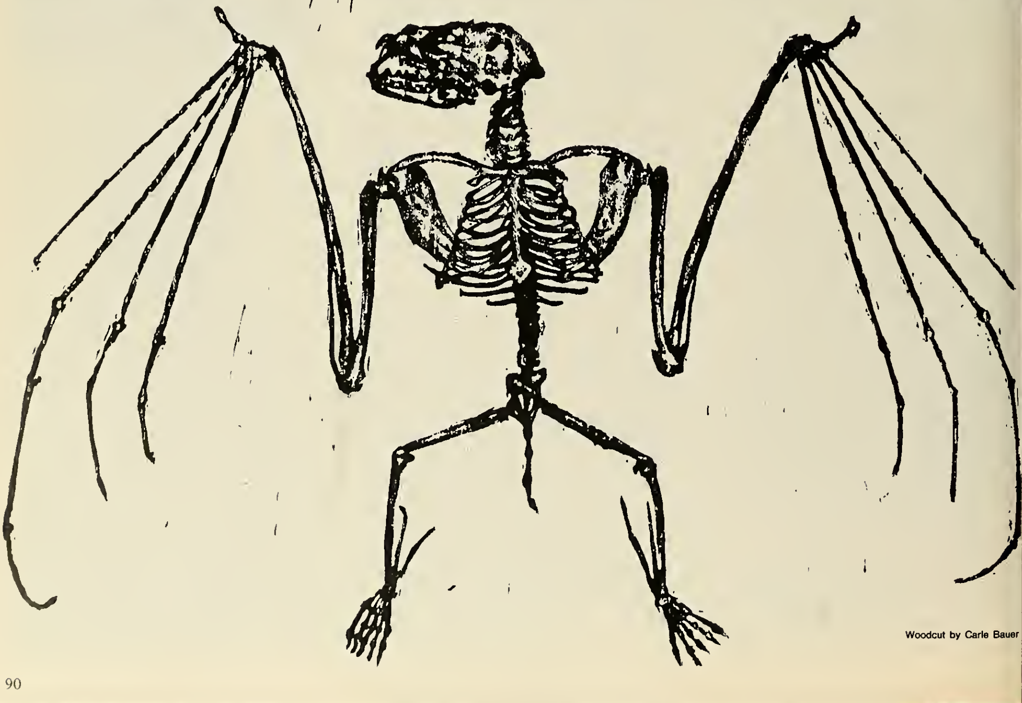
Lying on the floor, arms outstretched, is the frozen body of a female gorilla. Stretched alongside her, also frozen, is a male jaguar. Shelves on the far side of the room hold stacks of skins, including tanned elephant hides from Teddy Roosevelt's collection awaiting the day when they will be used to restore the elephant herd in the Akeley Hall of African Mammals. Assorted animal remains and skinned carcasses in plastic bags are scattered about the room, and in the far corner, two Siberian tigers stare at the scene with fierce but sightless eyes.

The mammalogy freezer is often the first stop a dead animal makes upon arrival at the American Museum of Natural History. Most animals are collected by curators and other scientists on field expeditions, but the Museum also receives animals that have died in zoos. The female gorilla, for example, died at the Bronx Zoo, and after an autopsy, she was given to the Museum.

Dead animals are useful to the Museum in several ways. Field specimens are used primarily for research (although some find their way to exhibition halls) and are valuable for a wide range of scientific studies in evolution, phylogeny, and taxonomy. Zoo animals may be used for research or teaching.

The problem Museum technicians face is how to reduce an animal—which may weigh up to 1,500 pounds—to skin and bones. The process, while fascinating, is not without its unpleasant aspects.

Bill Coull is the senior technician in charge of preparing animal skins. The tannery where Coull works is across the hall from the freezer; among other



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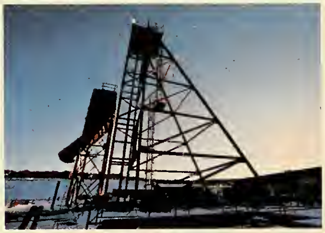

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tanning equipment it contains vats, beaming boards, and sawdust tumblers. The skull of a pigmy right whale, which Coull is repairing, dominates the center of the room, and trophy heads donated by generations of sportsmen hang on the walls. The tannery adjoins a large room where mounted specimens from former exhibits are stored.

The first step in preparing a hide Coull explains, is to remove it from th animal. When a large animal, such a the gorilla, is frozen, it will take several days to thaw out, so Coull ofte paints parts of the skin wit formaldehyde to retard spoilage. Afte skinning the animal, Coull throws th skin over a beaming board and removes excess fat and flesh with

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beaming knife, a technique thousands of years old. When the skin is reasonably clean, Coull shaves it to a uniform thickness with an electric shaving knife, removes cartilage from the ears and nose, and splits the double layer of skin around the lips and eyes.

The skin is now ready to be tanned. Coull soaks it for ten days in a solution of salt, alum, and soda ash to preserve it and render it pliable. In the final stage of skin preparation, he rubs neat's-foot oil into the hide and allows the oil to soak in. When the skin is dry, he puts it into a sawdust-filled nine-foot drum where it tumbles for about an hour to remove excess oil.

The carcass is another story. It may either be reduced to bones immediately or refrozen for future preparation. Steve Medina is the senior technician in charge of osteological preparation. "There are," he says, "two primary methods of preparing a carcass—bacterial maceration and the bugs." Maceration is used for large animals whose skeletons do not need to remain articulated, while the "bugs" (dermestid beetles) work best for smaller animals and for portions of bigger animals when curators want the complex skeletal parts to remain articulated. Maceration takes place in the osteology preparation area, a large, sunny room that looks out over Columbus Avenue. Along one wall are six tanks: three small, stainless steel sinks, two converted bathtubs, and one enormous vat used for macerating larger animals, such as whales and elephants, and for bleaching bones that will be used for exhibition.

The first step in bacterial maceration is to "rough out" the carcass by eviscerating it and trimming off excess muscle and tissue. "You don't want to take off too much," says Medina, "otherwise it will take longer to macerate thoroughly." The roughed-out carcass is placed in a tank of lukewarm tapwater, where it remains for perhaps a week. During that time, bacterial action digests and dissolves muscle, fat, and other tissues, which float to the surface as a scum that is easily drained off, leaving the bones behind. The bones are finally boiled in a solution of cleaning soda, and any remaining bits of tissue are removed by hand. Maceration, as you can imagine, generates quantities of unpleasant gas. Although large vents above the tanks draw off most of the rising vapors, Medina says that "it can get pretty bad in here."

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the famed dermestid beetles are the preferred method. These small, voracious beetles eat the flesh of an animal, leaving behind a spick-and-span, articulated skeleton. The dermestids have attracted much attention from the press and have been featured in the *New York Times* and the *Washington Post*. Visitors to the dermestid room—a dark, humid chamber in which the beetles thrive—must negotiate an assortment of specimens in alcohol, mounted specimens, and an ancient plaster cast of an elephant ear.

The beetles' current assignment is some fifty dried bats, a monkey, a fox, and an iguana. Given the right conditions, the dermestids take about a week to polish off an animal, at which time they are lured off the bones by a new feast. The clean skeletons are then

**Peruvian Weaving**

For forty-five centuries the weavers of Peru created intricate and sophisticated textiles. For the May members' program, Wednesday, May 14, at 7:30 P.M., in the Auditorium, Junius Bird and John Cohen will use contemporary and archeological evidence to discuss the weavings of Peru and will première Cohen's new film *The Weavers of Peru*. Members are admitted free, nonmembers may purchase tickets for $3.00 at the door.

**Glass Menagerie**

A menagerie of insects and other arthropods will be displayed in the Education Hall on Sunday, May 11, from 11:30 A.M. to 2:30 P.M. *Insect Day*, the May family membership program, will feature live tarantulas, black widow spiders, centipedes, scorpions, and cockroaches—all safely ensconced behind glass. Museum curators will also be exhibiting some of their favorite mounted specimens from the collection. *Insect Day* is open only to members of the Museum and their guests.

**The Past Researched**

The New York Society of the Archeological Institute of America and the Museum's Department of Education are presenting *Visions of Antiquity*, a film series that deals with different aspects of several archeological excavations. Excavations in Egypt, on the island of Thera (Santorini), and of a sunken Greek ship will be the focus of three Monday evenings, beginning May 5. Filmmakers laced in a sealed cabinet with moth-alls to kill any stray beetles, which ould otherwise continue to gorge hemselves on specimens in the collec-ions. A final immersion in a solution f ammonia removes any remaining rease, odor, and bits of tissue from he bones; after this, they are dried, la-eled, and matched with their skins nd other parts before being installed n the research collections.

Such specimens are now ready to be tudied by Museum curators, outside cientists, and graduate students. Last ear, the Museum's Department of Mammalogy made more than 300 oans, involving 4,000 specimens (most repared with the above methods), to cientists and institutions around the world.

*Douglas J. Preston*

and archeologists will lead informal discussions after two programs. For tickets, write the Department of Education at the Museum.

**Insect and Spider Films**

The Museum's Department of Education is offering a free weekend film festival, *Insects and Spiders*, on May 10 and 11 from 2:00 to 4:30 P.M. in the Auditorium. The films explore the lives and habits of butterflies, bees, spiders, ants, termites, and other small creatures.

**Feather Arts**

A new exhibition at the Museum explores the use of feathers in art, religion, and decoration. *Feather Arts: Beauty, Wealth, and Spirit from Five Continents* covers 1,000 years of history, features 250 artifacts made of feathers, and is illustrated with historical photographs, engravings, and brilliant mounted bird specimens. Some highlights of the exhibition are an effigy of the Hawaiian war god Kukailimoku, collected by Capt. James Cook; feather baskets made by the Pomo Indians of California; and a White Mountain Apache war headdress.

**New Guinea Headdresses**

A companion exhibit to *Feather Arts* explores the complexity and variety of headdresses from New Guinea and includes photographs of the birds of paradise used to create them. *Papua New Guinea: A Feather in the Cap* will remain on display in the Akeley Gallery until September 1.

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# In Search of a Proper Tillamook

*The demand for Oregon's own cheddar cheese leaves little time for aging*

**by Raymond Sokolov**

First there were the mountains of the Coast Ranges and, in between them, lush green meadows. The climate was mild and grass grew thick all year. This dairyman's utopia was what Joe Champion saw when he landed by whale boat in Tillamook Bay one April morning in 1851. Champion had sailed down the Oregon coast from Astoria at the mouth of the Columbia River to settle this remote but lovely corner of the earth.

"The Indians," wrote Champion, "generally seemed pleased with the prospect of having the whites to settle among them [poor fools].

"They showed me a large hollow Spruce Tree into which we conveyed all my property."

He lived in the tree for a month and then built a cabin. That same year, other rugged pioneers followed Champion to Tillamook, driving herds of cattle that waxed fat on the pristine pasture and gave milk in wonderful abundance. But there was no practical way to ship the milk out of Tillamook. The only land route over the summit of the Coast Ranges was an Indian track. The county did not get a rail connection with the outside world until 1911. Boats were undependable and slow. Milk was bulky and perishable.

Cheese was the answer. It was compact and kept extremely well. So the Tillamook pioneers made cheese from their milk and in 1855 built a ship called the *Morning Star* to carry it up the Columbia River to market.

Little cheese factories sprang up everywhere, amateur operations that resulted in a bewildering array of cheeses—some good, some bad. Eventually, in 1894, an itinerant cheesemaker from Ontario, Peter McIntosh, introduced the standard cheddar process he had learned back east.

By 1894, cheddar was already an established part of life in many parts of North America. The first cheddar factory in the United States had been set up in 1851 by Jesse Williams near Rome, New York. This hard, bacterially cultured whole-milk pressed cheese was British in origin, where it was invented some time before 1664, in the Somersetshire village of Cheddar, near Bristol. Yet it assimilated itself in the New World so well that it was often known as American cheese. New Englanders spoke of it familiarly as rat cheese or store cheese.

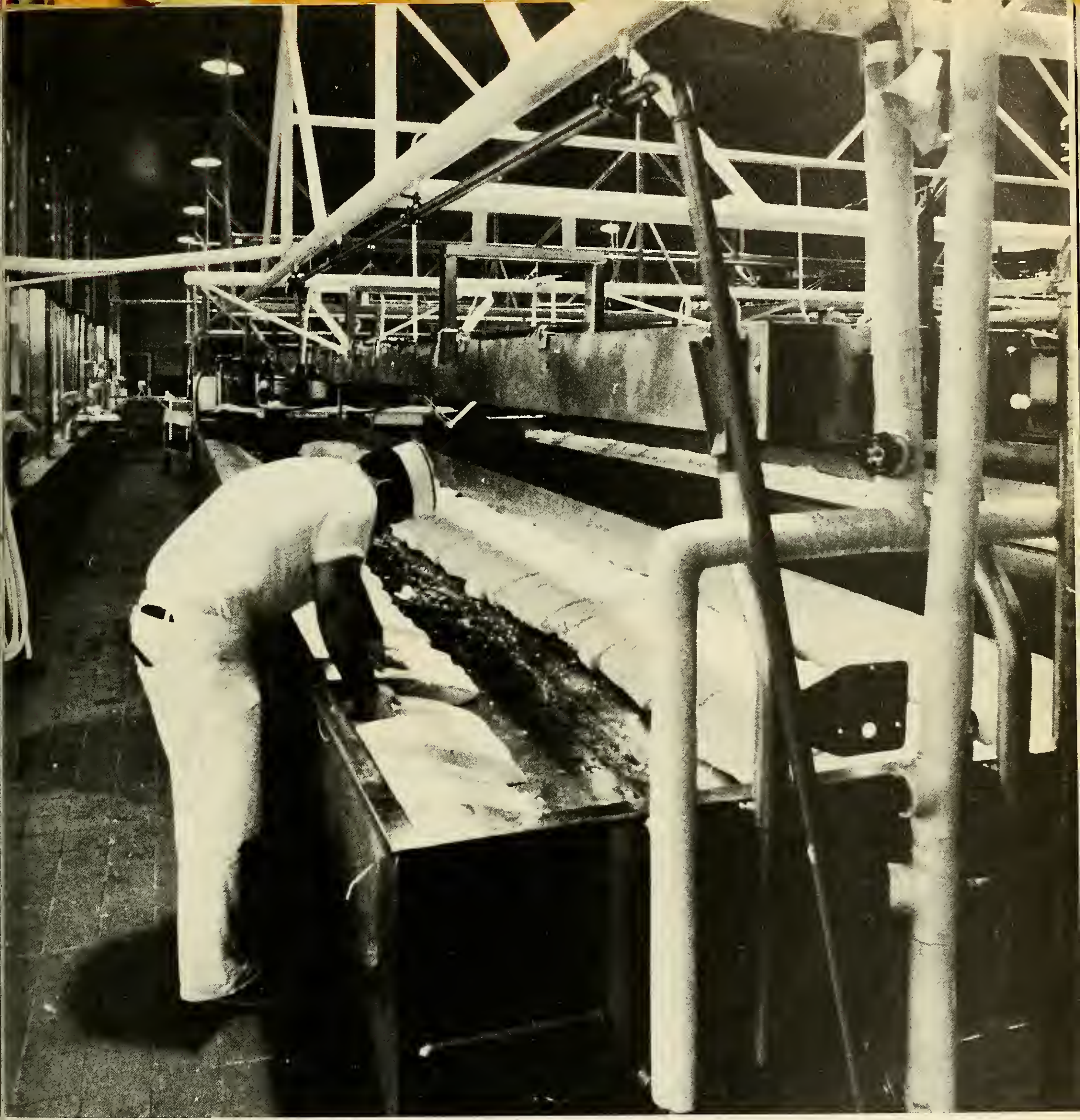
Tillamook cheddar ought to have been just another example of the same ubiquitous product. But those sturdy Pacific Northwest yeomen who made it aged their cheddar longer than the standard six or seven months. They liked their cheese as sharp and mature as possible. Two whole years of curing was not unusual.

Something else crucial separated the Tillamook cheesemakers from their competitors in other places, even from those in other locations along the Oregon coast. The Tillamook factories had a flair for modern marketing. As early as 1909, they banded together as the Tillamook County Creamery Association, standardized their production, and adopted Tillamook as an exclusive trade name.

Today, you can learn all about the progressive consolidation of the Tillamook factories in the museum at the giant plant on Highway 101 just north of the town of Tillamook. Out in front is a full-scale replica of the *Morning Star*, which is the Tillamook logo.

The plant itself is now the only factory producing cheese for the Tillamook label. It is a model of spotless, automated mass production and worlds apart from the cheesemaking of olden days commemorated in the exhibit of antique cheese vats and tools in the plant museum or from the battered fifty-gallon copper cheese kettle in the Pioneer Museum in town.

In the visitors' observation area of the plant, you can watch the cheesemaking process through a glass wall. Oregon's strict health laws forbid visitors going out on the plant floor, but the overhead view of the five 15,500-quart vats is dramatic all the same. A sea of milk cultured with lactobacilli and rennet curdles while automatic stirring devices sweep slowly through the vats. Whey gradually drains out of the vats, leaving behind curds that remind you of scrambled eggs. Then a man appears. He cuts a lengthwise ditch down the middle of the vat, leaving the curd packed together on either side. In a few minutes, the curd is firm enough to be turned without breaking and it is time for him to "cheddar" the cheese. He cuts the curd into slabs several inches wide. He works with machinelike precision, cutting dozens o identical loaves of curd, then turning them so that whey runs out uniformly and rapidly. The firm slabs then trave on a conveyor belt to a milling machine that cuts them into fingerlike pieces, washes them, adds a smal amount of salt, and packs them in hoops.



*Cheese kitchens, Tillamook Cheese Factory*

Scott Blackman

Each hoop holds forty pounds of curd, which is pressed for three hours. The pressed blocks go into a curing area with a ten-million-pound capacity, where the temperature is always 38 degrees Fahrenheit. Federal law requires that cheddar be cured for sixty days. Medium Tillamook is, in fact, cured for three months. The sharp cheddar ages for seven months.

On my way out of the observation area, I walked through the factory gift shop and bought some sharp cheese. In the parking lot, I cut into the package, feeling in direct contact with Tillamook pioneer days as the annatto-colored cheese emerged. The Coast Ranges loomed on the horizon. *Morning Star II* was only a few feet away. I tasted the cheese.

It was mediocre. Not bad. Clearly a cheddar, with a respectable tang to it, but not the stellar cheese I had once tasted in the home of a New York epicure whose Oregonian wife had imported it from a special source in her home state.

But I had been warned. James Beard, himself an Oregonian, had told me I would probably not find old-fashioned, aged Tillamook cheese in Oregon. The demand is too great these days. The cost of holding the cheese in the curing room for two years is prohibitive. M. Wayne Jensen, Jr., director of the Pioneer Museum and the son of a cheesemaker, told me much the same thing. He remembered when farmers used to leave cheeses in the factory curing area to age like cigars in the Dunhill humidor room. He even remembered tasting a cheddar that had been cured right through World War II. "It was a bit crumbly," he conceded, "but good, good and sharp." Nevertheless, he didn't know where I would find even a two-year-old cheese today.

James Beard had suggested that I might ask around at the factory. Some of the employees might be aging cheese at home. I left my car and accosted the first worker I saw. "Yes," she said, "I've got some in my refrigerator right now. I keep it sealed in the back of the vegetable drawer for two years. Just turn it once a week."

If I wanted to buy some old cheddar, she said, I might try at the market up the coast in Bay City.

The C & W Markette is a little country store in a very small town. You would not ordinarily stop there on your way north along the gorgeous coastal highway. And even if you did, you would probably notice nothing special about the place except for the homemade beef jerky in the meat department. But the well-informed turophile at the C & W walks briskly to the back of the store and snaps up some peculiar little packages of cheddar in plastic bags. They sell for more than the brand-name cheddar in the same display area, but the price is not at all outlandish: $3.45 per pound. They look just like other cheddars, but they are sublime. Not aggressively sharp, yet undeniably vigorous, these special cheeses are luxuriously dense but not at all crumbly. They are, indeed, curiously smooth, with a complexity of taste that would make Peter McIntosh proud.

"I buy medium cheddar from the factory by the ton," says Frank Walz, proprietor of the C & W. "Then I age it at 32 degrees for three years. It's easier that way. It would go faster at 55, but I'd have to turn it all the time."

Tradition dies hard in Oregon. The Tillamook central plant keeps the legend of its cheese alive, and it manufactures the raw material for traditional aged cheese. Frank Walz, who migrated west from Minneapolis twenty years ago, does the rest. And in my New York refrigerator, five pounds of factory-sealed cheese sits quietly in the back of the vegetable drawer. I turn it from time to time, thinking of pacific cows, thick grass, and Joe Champion in his hollow spruce.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

*Tillamook Cheese Factory, 1913*

Tillamook County Pioneer Museum

### Oregon Fish and Cheese Casserole

(Adapted from Carol Cate's *Clam Dishes and Rock Fishes*, available from Carol's Cookbooks, P.O. Box 795, Winchester, Oregon 97495)

1½ pounds rockfish (fleshy white fish) fillets
1 teaspoon salt
¼ teaspoon pepper
1 cup whole-kernel corn
1½ cups green beans, cooked
2 cups cooked potatoes, sliced
¼ cup butter or margarine
2 tablespoons lemon juice
2 tablespoons grated onion
1 tablespoon chopped parsley
2 medium tomatoes, peeled and sliced
¼ cup grated cheddar cheese (1 ounce)

1. Cut fish into 3 or 4 serving-size portions and sprinkle with half the salt and pepper. Preheat oven to 350 degrees.
2. In a large, well-greased casserole, place in layers the corn, green beans, and potatoes, sprinkling each layer with the remaining salt and pepper.
3. Combine butter or margarine, lemon juice, onion, and parsley. Dip fish into mixture and arrange on top of potatoes. Cover with tomato slices and cheese.
4. Bake 1 hour and 15 minutes or until fish flakes.

Yield: Three to four servings

### Welsh Rarebit

(From Bert Greene's *Kitchen Bouquets*, Contemporary Books)

2 tablespoons unsalted butter
3 egg yolks
1 teaspoon Dijon mustard
½ teaspoon beef bouillon powder
1 teaspoon imported soy sauce
Dash of hot pepper sauce
Pinch of ground allspice
¾ cup light beer
10 ounces sharp cheddar, grated
1 tablespoon heavy cream
1 teaspoon Scotch whiskey
4 slices hot buttered toast

1. Melt butter in a double boiler.
2. Beat the egg yolks with the Dijon mustard, bouillon powder, soy sauce, hot pepper sauce, and allspice. Stir in the beer.
3. Add the beer mixture to the melted butter; place over simmering water. Stir until hot. Add the grated cheese, ¼ cup at a time, stirring constantly in one direction with a wooden spoon until mixture is smooth.
4. Stir in the cream and Scotch. Do not let mixture stand more than 5 minutes before serving over hot, buttered toast.

Yield: Four servings

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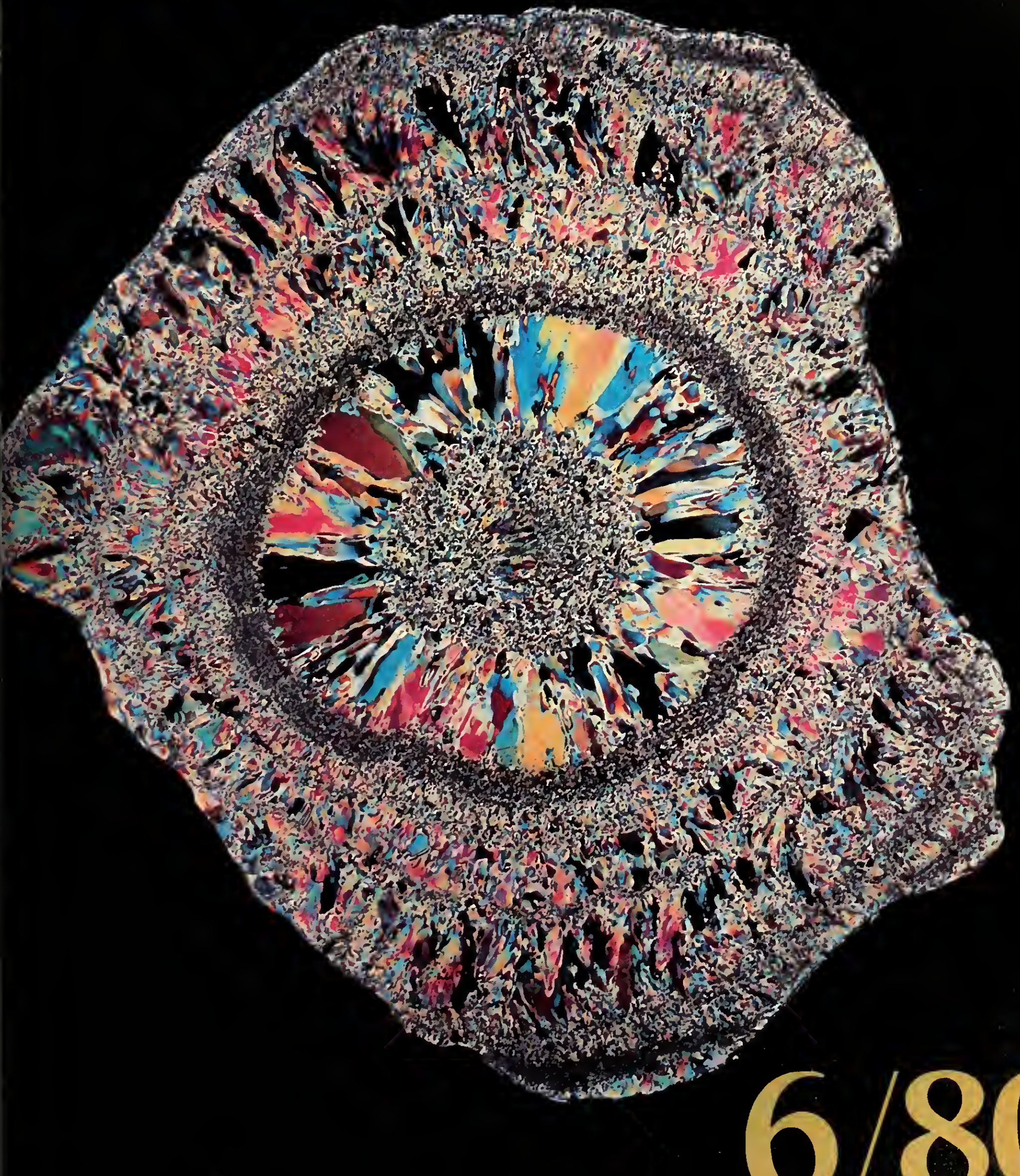

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If one accepts the dismal prophecies emanating from the automotive community, it appears we are destined to suffer a generation of thoroughly boring automobiles.

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All this pessimistic doomsaying, however, neglects to take into account the obsessive determination of the engineers at BMW in Munich, Germany to build extraordinary automobiles.

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(Naturally, our fuel efficiency figures are for comparison purposes only. Your actual mileage and range may vary, depending on speed, weather and trip length. Your actual highway mileage and highway range will most likely be lower.)

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# NATURAL HISTORY

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Soon after arriving as a student at Florida Southern University from his native Baltimore, **David S. Lee** noticed the conspicuous mounds of pocket gophers dotting the landscape. Six years ago, having taken a position with the Florida State Museum, he began to study the elusive, subterranean rodents that were responsible for the mounds. At present, Lee is curator of birds and mammals at the North Carolina Museum of Natural History and goes afield every year to observe more of the life style of the pocket gopher. He is also involved in an extensive study of the sea birds of North Carolina's offshore waters. A writer and photographer as well as a biologist, Lee has developed an avocational interest in native orchids and ferns.

As a boy in Maine, **Bernd Heinrich** was already involved with caterpillars; he hunted them to raise into moths and butterflies. His subsequent Ph.D. work at the University of California at Los Angeles began as a project on the feeding behavior of sphinx moth caterpillars, but ended as a study of temperature regulation in the moths themselves. A professor of entomology at the University of California at Berkeley, Heinrich now concentrates his research on the physiology and behavior of foraging insects, a subject he covered in his recent book, *Bumblebee Economics* (Harvard University Press, 1979). He is also a marathon runner and last February, at age 39, set his best time for the 26-mile, 385-yard course—2 hours 22 minutes. (The Olympic record is 2 hours 9 minutes 55 seconds.)

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Cloud physics is **John Hallett**'s particular interest, in pursuit of which he flies through storms in research aircraft and conducts laboratory and field studies on growth processes of hailstones and snow crystals. Born and educated in England, Hallett has lived in the United States for two decades. He is research professor of atmospheric physics at the Desert Research Institute of the University of Nevada and concurrently teaches graduate and undergraduate courses in atmospheric and environmental science.

**Reid A. Bryson** is a professor of meteorology and geography at the University of Wisconsin, Madison, and since 1970 has been director of the university's Institute for Environmental Studies. In line with his interdisciplinary approach to subjects under investigation, he has applied climatic information to cultural changes among North American Plains peoples. Bryson has been on archeological digs in Canada and the United States, has studied climatic modification in India, and has written widely on climatic subjects for scientific journals and the popular press. Future research projects include an effort to develop a unified theory of climatic changes.

**Dmitri Ivanovich Bibikov** is a senior researcher with the Institute of Evolutionary Animal Morphology and Ecology of the USSR Academy of Sciences in Moscow. His current research into the ecology of carnivores and rodents also embraces the field of medical zoology. In 1972, while attending the General Assembly of the International Union for the Conservation of Nature in Banff, Canada, he participated in that organization's Wolf Working Group. That triggered his interest in wolves, one that he is still pursuing, along with his earlier studies of marmots. Bibikov has done fieldwork in central Russia, the Caucasus, the Trans-Baikal region, the Far East, the mountains of Central Asia, and the deserts of Kazakhstan. He lists his hobbies as hunting and fishing.

## Bells Toll Warning to Whales

"When we wrote that article, the fishermen saw no way out except killing whales," Jon Lien recalls of the situation in Newfoundland last spring. As he and Bora Merdsoy reported in "The Humpback Is Not Over the Hump" (June/July 1979), whales chasing capelin, a small fish that codfish also feed on, were becoming entangled in cod traps, wreaking economic havoc on the fishermen.

Now things have improved somewhat. When they wrote the article, Lien and Merdsoy had just developed a means to extricate whales from traps, and they have since refined it. More important, they came up with a workable and inexpensive device to warn whales off cod traps, which are set just under the surface. By attaching an underwater bell, which costs about $2.50, to the traps, they were able to drastically reduce whale entanglements. In tests, 89 percent of the traps without bells were hit by whales while only 30 percent of the traps with bells suffered whale damage.

Lien and Merdsoy are still experimenting with warning devices for gill nets, which are set so deep that the bells will not work, but not so deep that the nets do not suffer whale damage. Nonetheless, the fishermen are not as frantic as they were. At least, says Lien, there were no petitions in Newfoundland last year to lift Canada's ban on whaling.

Whale Research Group

*A team from the Memorial University of Newfoundland extricates a dead humpback whale from a cod trap.*

## The Origin of "Winter Sleep"

When Henry Van Twyver and Truett Allison wrote "The Evolution of Sleep" (February 1970), they speculated that among the blessings of slumber for mammals was energy conservation. Since they need to maintain a constant body temperature, warm-blooded animals have high energy demands, and Van Twyver and Allison proposed that sleep could have evolved as a way for such animals to "turn down the body's 'thermostat' and conserve energy."

Apparently, they were on the right track. Recent work with small mammals by Craig Heller of Stanford University and Ralph Berger of the University of California at Santa Cruz

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# HOW GM "PROJECT CENTERS" CREATE CARS

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Throughout the history of the automobile industry, product change was almost always evolutionary. But in 1973, GM determined that the times required revolutionary changes. It started its first Project Center—which by itself heralded a revolution in the use of science and technology to meet the changing demands of the marketplace. A few months later, the Arab countries launched the oil embargo. Fortunately, machinery was already in motion in GM to create and develop new cars and components in a new way and faster than ever before.

**GM's first Project Center brought out totally new full-size cars:** smaller, yet roomier, and far more efficient than their predecessors. The advertisements said they were "designed and engineered for a changing world"—and they were. Another Project Center, begun in 1975, developed the immensely popular GM X-cars.

Led by the five car divisions, Project Centers gather people, ideas, and knowledge from all 30 divisions and staffs of General Motors. In the first stage, which we call "concepting," experimental engineers, environmental scientists, forward planners, and marketing experts pool their thinking. Their objective: what the marketplace will require. This is the most important stage. Here we must determine not only what kind of car, but how many we might be able to build and sell years later. Economics, customer tastes, availability of various kinds of fuels must be compared with state-of-the-art technology—and what steps must be taken to advance that technology quickly yet surely.

In the "concepting" stage, a new car is conceived. If the car is to be sold to customers three years later, construction of new plants must begin and basic tooling must be ordered.

The second phase of the Project Center takes 24 to 30 months. It encompasses development, design, structural analysis, handling analysis, emissions, noise and vibration, safety, reliability, serviceability and repairability, manufacturing, assembly, marketing, financing.

Advanced product engineers and research scientists work with the one hundred fifty to two hundred people at the Project Center and thousands more in the staffs and divisions to transfer new science and technology to the new car. Components are hand-built and "cobbled" into existing models for road testing.

**Prototype cars are hand-built at a cost of more than $250,000 each.** These enable the Project Center team to determine how newly developed, pretested components operate as a unit. Then, pilot models will be built from production tooling and tested some more. New technology, such as structural analysis by computer, saves time. Lead time has been reduced by 25% from ten years ago, when cars were far less complex.

After almost four million miles, nearly three billion dollars, and nearly three years of work, the new cars—quite unlike anything before them—start coming off the production line at a rate of better than one a minute.

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SMALL WONDER

NIKON ROOF PRISM COMPACT BINOCULARS

supports the view of sleep as intimately connected with temperature regulation. Heller says their studies suggest that hibernation, which involves greatly lowered body temperatures and has a clear energy-conserving function, is an evolutionary extension of sleep—actually of one kind of sleep called slow-wave sleep.

He also points out that this notion has been anticipated in the common parlance of biologists, who called hibernation "winter sleep," and in the German language, in which the word for hibernation is essentially the same—*Winterschlaf*.

This new view of hibernation is based on several lines of evidence. During both hibernation and slow-wave sleep a part of the brain known as the hypothalamus regulates body temperature. And during both hibernation and slow-wave sleep body temperature drops.

Furthermore, hibernating mammals descend into hibernation through slow-wave sleep. Recordings of electrical impulses from the brain show an increasing predominance of slow waves until an animal reaches 77°F, below which one can't get a good EEG (electroencephalogram). Animals that go into shallow torpor—a state between sleep and hibernation in which body temperature drops a few degrees—show a predominance of slow waves throughout their torpor greater than that during normal sleep.

These similarities in EEG and temperature regulation, says Heller, put sleep, shallow torpor, and hibernation on a continuum, and suggest that hibernation is not an evolutionarily primitive phenomenon but a specialized adaptation that evolved out of slow-wave sleep.

What is not on the continuum is the other kind of sleep—called REM (rapid eye movement), or paradoxical, sleep. During this kind of sleep the eyes move rapidly and the brain exhibits electrical activity that resembles the pattern of wakefulness, while the muscles (paradoxically) lack tone, leaving the body effectively paralyzed. What puts REM sleep off the continuum is that it is also characterized by a lack of thermoregulation. The hypothalamic temperature control present at other times is absent.

Why it is absent is as much of a puzzle as REM sleep itself, for which a physiological explanation, according to Heller, is not yet in sight.

*James Gorman*

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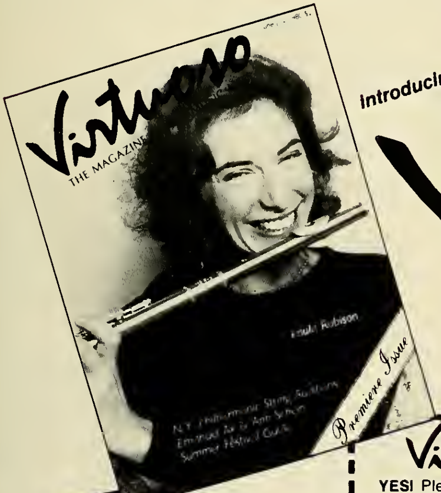

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# “Everyone Here Spoke Sign Language”

*For many generations on Martha’s Vineyard, deafness was no bar to a full social life*

**by Nora Groce**

The fifth of April, 1715, had not been a good day for Judge Samuel Sewell of Boston. On his way to the island of Martha’s Vineyard there had been trouble finding a boat to cross Nantucket Sound. The vessel then lay for hours without wind, and once it was across, the horses had to be pushed overboard to swim for shore on their own. Sewell and his company reached shore at dusk—cold, hungry, and in bad humor. Finding a group of local fishermen nearby, the judge engaged one of them to guide him to Edgartown and later noted in his diary: “We were ready to be offended that an Englishman . . . in the company spake not a word to us. But,” he continued by way of explanation, “it seems he is deaf and dumb.”

This Englishman was indeed deaf, as were two of his seven children. His is the first recorded case of what we now know to be a form of inherited deafness that was to appear consistently within this island population for more than 250 years and affect dozens of individuals. Probably one or several of the small number of settlers who originally populated the area brought with them a trait for hereditary deafness. As long as the “gene pool” remained limited in the small island population, this trait appeared with high frequency in subsequent generations. Put another way, the founders of this isolated society had a greater likelihood of perpetuating the trait for congenital deafness than if they had been part of a larger, changing population.

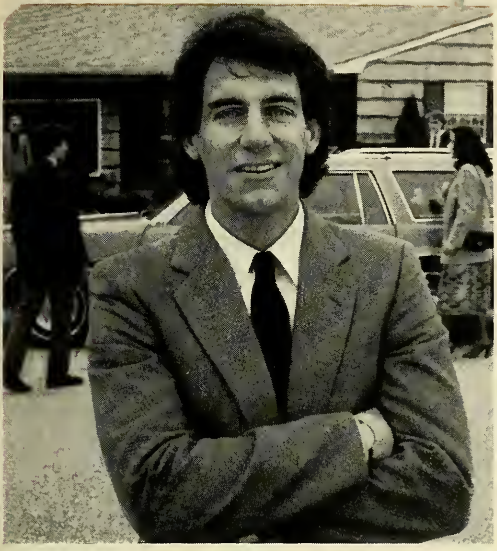
Martha’s Vineyard offers what I feel to be a good example of the way in which a community adapts to a hereditary disorder. Lying some five miles off the southeastern coast of Massachusetts, the island was first settled by Europeans in the early 1640s. The population, of predominantly English stock with some admixture of indigenous Wampanoag Indian, expanded rapidly, owing to a tremendously high birthrate. Families that had fifteen to twenty children were not uncommon and twenty-five to thirty not unheard of. Although several hundred households are listed in the census records of the mid-eighteenth century, only about thirty surnames are to be found, and during the next century and a half only a handful more were added to the original group of names.

After the first generation, marriage “off-island” was rare. While Vineyard men sailed around the world on whaleships, merchantmen, and fishing vessels, they almost invariably returned home to marry local girls and settle

POST OFFICE

*This post office-general store was often the scene of sign-language conversations.*

Courtesy of Stanton Lair, Martha’s Vineyar



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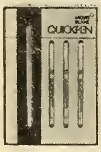

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down. Women married off-island even less frequently than did the men. Contact with the mainland was said to be more sporadic than with foreign countries. In the nineteenth century, islanders claimed that more of their men had been to China than to Boston, only eighty miles away. Even today, many islanders have never been to the island of Nantucket, barely eight miles to the east.

Throughout the seventeenth, eighteenth, and nineteenth centuries, marriage patterns on the island followed the customs of any small New England community. Most of the islanders, however, could trace their descent to the same small nucleus of original settlers, indicating that although they were unaware of it, considerable "inbreeding" took place. The result was that during these two and a half centuries, within a population averaging little more than 3,100 individuals, hereditary deafness occurred at a rate many times that of the national population. For example, in the latter part of the nineteenth century, an estimated one out of every 2,730 Americans was born deaf. On Martha's Vineyard the rate was closer to one out of every 155. But even this figure does not accurately represent the distribution of deafness on the Vineyard.

Marriages were usually contracted between members of the same village, creating smaller groups *within* the island's population characterized by a higher frequency of deafness. The greatest concentration occurred in one village on the western part of the island where, by my analysis, within a population of 500, one in every twenty-five individuals was deaf. And even there the distribution was not uniform, for in one area of the village during this time period, one out of every four persons was born deaf.

The high rate of deafness on the island brought only occasional comment from island visitors over the years. Because most of the island deaf lived in the more remote areas of the island, few off-islanders were aware of their presence. Vineyarders themselves, used to a sizable deaf population, saw nothing unusual in this, and many assumed that all communities had a similar number of deaf members. Almost nothing exists in the written records to indicate who was or was not deaf, and indeed, only a passing reference made by an older islander directed my attention to the fact that there had been any deaf there at all.

While most of my information on i land deafness has been obtained fro the living oral history of islanders no in their seventies, eighties, and nin ties, part of my genealogical data wa acquired from the only other study this deaf population. I came to know it when an 86-year-old woman I wa interviewing recalled that her mothe had mentioned a "teacher of the dea from Boston" at one time taking a interest in the island deaf. Thi "teacher of the deaf" turned out to b Alexander Graham Bell, who, havin recently invented the telephone turned his attention back to his lifelong interest in deafness research Concerned with the question of heredity as it related to deafness, Bell bega a major research project in the earl 1880s, which was never completed.

Nineteenth-century scholars, without the benefit of Mendel's concept o unit factor inheritance (which only received widespread circulation at th turn of the century, although it ha been published in the 1860s), were at loss to explain why some but not al children of a deaf parent were themselves deaf. Selecting New Englan because of the older and unusuall complete records available, Bell believed that by tracing back the genealogy of every family with two or mor deaf children, he could establish som pattern for the inheritance of deafness He soon found that practically ever family in New England with a histor of deafness was in some way connecte with the early settlers of Martha's Vineyard, but he was unable to account for the fact that a deaf parent di not always have deaf children and s he abandoned the study. Although Bell never published his material, he left dozens of genealogical charts that have proved invaluable for my research—particularly because they corroborate the information I have been able to collect from the oral history of the older islanders.

Since Bell's time, scientists have found, through the construction and analysis of family pedigrees and the use of mathematical models, that congenital deafness may result from several causes: spontaneous mutations involving one or more genes; an already established dominant or recessive inheritance, as Mendel demonstrated; or factors otherwise altering normal development of the ear and its pathways to the brain. Human populations, of course, cannot be studied with the same exactness as a laboratory experi-

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ment. However, the appearance of apparently congenitally deaf individuals is far too frequent on Martha's Vineyard to be mere coincidence, and the evidence collected thus far points to a recessive mode of inheritance.

While the genetic nature of a hereditary disorder in small populations is something that both anthropologists and geneticists have studied, there is another question, rarely addressed, that is of equal importance: How does the population of a community in which a hereditary disorder exists adjust to that disorder—particularly one as prominent as deafness? In modern society the emphasis has been on having "handicapped" individuals adapt to the greater society. But the perception of a handicap, with its associated physical and social limitations, is tempered by the community in which it is found. The manner in which the deaf of Martha's Vineyard were treated provides an interesting example of how one community responded to this type of situation. "How," I asked my informants, "were the island deaf able to communicate with you when they could not speak?" "Oh," I was told, "there was no problem at all. You see, everyone here spoke sign language."

From the late seventeenth century to the early years of the twentieth, islanders, particularly those from the western section where the largest number of deaf individuals lived, maintained a bilingual speech community based on spoken English and sign language. What is of particular interest is that the use of sign language played an important role in day-to-day life.

Islanders acquired a knowledge of sign language in childhood. They were usually taught by parents, with further reinforcement coming from the surrounding community, both hearing and deaf. For example, recalling how she learned a particular sign, one elderly woman explained:

> When I was a little girl, I knew many of the signs, and the manual alphabet of course, but I didn't know how to say "Merry Christmas," and I wanted to tell Mr. M. "Merry Christmas." So I asked Mrs. M., his wife. She could hear and she showed me how. And so I wished Mr. M. "Merry Christmas"—and he was just so delighted.

This women then described how she taught her son, now in his late seventies, how to speak the language.

> When my son was perhaps three years old, I taught him to say in sign language "the little cat and dog and baby." This man, who was deaf, he used to like to go down to our little general store and see people come and go. One day when I went down there, I took my son there and I said to him, "Go over and say 'how-do-you-do' to Mr. T.," the deaf man. So he went right over, and then I told him to tell Mr. T. so-and-so—a cat, a dog, and whatever. And wasn't Mr. T. tickled! Oh, he was so pleased to know a little bit of a boy like that was telling him all those things, and so he just taught my son a few more words. That's how he learned. That's how we all learned.

Particularly in the western section of the island, if an immediate member of the family was not deaf, a neighbor, friend, or close relative of a friend was likely to be. Practically all my "up-island" informants above the age of seventy remembered signs, a good indication of the extent to which the language was known and used. In this section, and to a lesser extent in the other villages on the island, sign language formed an integral part of all communications. For example, all informants remembered the deaf participating freely in discussions. One remarked:

> If there were several people present and there was a deaf man or woman in the crowd, he'd take upon himself the discussion of anything, jokes or news or anything like that. They always had a part in it, they were never excluded.

As in all New England communities, gathering around the potbellied stove or on the front porch of what served as a combination general store and post office provided a focal point for stories, news, and gossip. Many of the people I have talked to distinctly remember the deaf members of the community in this situation. As one man recalled:

> We would sit around and wait for the mail to come in and just talk. And the deaf would be there, everyone would be there. And they were part of the crowd, and they were accepted. They were fishermen and farmers and everything else. And they wanted to find out the news just as much as the rest of us. And oftentimes people would tell stories and make signs at the same time so everyone could follow him together. Of course, sometimes, if there were more deaf than hearing there, everyone would speak sign language—just to be polite, you know.

The use of sign was not confined to small group discussions. It also found its way into assembled crowds. For example, one gentleman told me:

> They would come to prayer meetings; most all of them were regular church people, you

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> know. They would come when people offered testimonials, and they would get up in front of the audience and stand there and give a whole lecture in sign. No one translated it to the audience because everyone knew what they were saying. And if there was anyone who missed something somewhere, somebody sitting near them would be able to tell them about it.

The deaf were so integral a part of the community that at town meetings up-island, a hearing person would stand at the side of the hall and cue the deaf in sign to let them know what vote was coming up next, thus allowing them to keep right on top of things. The participation of the deaf in all day-to-day work and play situations contrasted with the manner in which those handicapped by deafness were generally treated in the United States during the same time period.

Sign language on the island was not restricted to those occasions when deaf and hearing were together, but was used on a regular basis between the hearing as well. For example, sign language was used on boats to give commands and among fishermen out in open water to discuss their catch. I was told:

> Fishermen, hauling pots outside in the Sound or off Gay Head, when they would be heaven knows how far apart, would discuss how the luck was running—all that sort of thing. These men could talk and hear all right, but it'd be too far to yell.

Indeed, signs were used any place the distance prohibited talking in a normal voice. For example, one man remembered:

> Jim had a shop down on the shore of Tisbury Pond, and his house was a ways away, up on the high land. When Trudy, his wife, wanted to tell Jim something, she'd come to the door, blow a fish horn, and Jim would step outside. He'd say, "Excuse me, Trudy wants me for something"; then she'd make signs to tell him what she needed done.

On those occasions when speaking was out of place, such as in church, school, or at some public gatherings, the hearing communicated through signs. Such stories as the following are common: "Ben and his brother could both talk and hear, but I've seen them sitting across from each other in town meetings or in church and telling each other funny stories in sign language."

Island people frequently maintained social distance and a sense of distinct identity in the presence of tourists by exchanging comments about them in sign language. The occurrence of what linguists call code switching from speech to sign also seems to have been used in certain instances. For example, I was told:

> People would start off a sentence in speaking and then finish it off in sign language, especially if they were saying something dirty. The punch line would often be in sign language. If there was a bunch of guys standing around the general store telling a [dirty] story and a woman walked in, they'd turn away from her and finish the story in sign language.

Perhaps the following anecdote best illustrates the unique way island sign language was integral to all aspects of life:

> My mother was in the New Bedford hospital—had an operation—and father went over in his boat and lived aboard his boat and went to the hospital to see her every night. Now the surgeon, when he left him in her room, said they mustn't speak, father couldn't say a word to her. So he didn't. But they made signs for about half an hour and mother got so worked up, they had to send father out, wouldn't let him stay any longer.

Sign language or rather sign languages—for even within this country there exist a number of distinct languages and dialects—are languages in their own right, systems of communication different from the spoken languages used by hearing members of the same community. It has often been noted that American Sign Language, the sign system commonly used among the deaf in the United States today, is influenced by French Sign Language, introduced to America in 1817. The data from Martha's Vineyard, however, clearly support the hypothesis, made by the linguist James Woodward, that local sign language systems were in use in America long before this. By 1817 (the year the American School for the Deaf was founded in Hartford, Connecticut), deaf individuals on Martha's Vineyard had been actively participating in island society for well over a century. Because they were on an equal footing, both socially and economically, with the hearing members of the community, and because they held town offices, married, raised families, and left legal and personal documents, there must have existed some sort of sign language system that allowed full communication with family, friends, and neighbors.

It may prove difficult to reconstruct the original sign language system used on the island during the seventeenth and eighteenth centuries, but study of this question is currently under way. Whatever the exact nature of the original language, we know that it later grew to acquire many aspects of the more widely used American Sign Language, as increasing numbers of deaf island children were sent to the school in Hartford during the nineteenth century. This combination of the indigenous sign system with the more standardized American Sign Language seems to have produced a sign language that was, in many respects, unique to the island of Martha's Vineyard. The most common remark made by islanders who still remember the language is that they find it very difficult or are completely unable to understand the sign language spoken by off-islanders or the translations for the deaf that are beginning to be seen on television.

The use of sign language as an active system of communication lessened as the number of individuals in the community with hereditary deafness gradually disappeared, the last few dying in the 1940s and early 1950s. This decrease in the number of deaf can be attributed to a shift in marriage patterns that began in the latter part of the nineteenth century, when both hearing and deaf islanders began to marry off-islanders. The introduction of new genes into the once small gene pool has reduced the chance of a reappearance of "island deafness."

As the number of islanders born deaf dwindled, younger generations no longer took an interest in learning sign language, and the older generations rarely had the need to make use of it. Today, very few people are left who can speak the language fluently, although bits and pieces of it can be recalled by several dozen of the oldest islanders. A few signs are still kept alive among those who knew the language and on a few of their fishing boats. As one gentleman, well along in his seventies, told me recently:

> You know, strangely enough, there's still vestiges of that left in the older families around here. Instinctively you make some such movement, and it means something to you, but it doesn't mean anything to the one you're talking to.

*This article presents some of the material Nora Groce has collected in researching her doctoral dissertation in anthropology at Brown University. Her work has been supported, in part, by a grant from the National Institute of Mental Health.*

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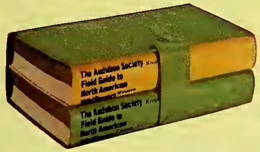
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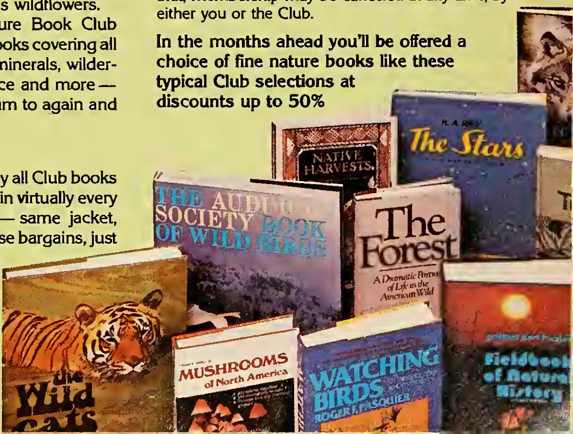
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# The Worm-Asthma Controversy

*Do certain worms cause, protect against, or have no connection with asthma?*

**by Robert S. Desowitz**

Every now and then those two Brahmins of the medical press, the *New England Journal of Medicine* and the British publication the *Lancet*, serve as forums for debates whose resolution affects the health of us all. Most of the arguments have been publicized in the popular press, for example, Does a fat free diet reduce the risk of cardiovascular disease? Do coronary bypass operations benefit the patient more than the surgeon? Another controversy, which has kindled a certain passion in a specialized coterie of followers of the papers and correspondence in these journals and elsewhere, has been whether parasitic worms can cause asthma. The affairs of the heart are well known but the worm-asthma debate is undoubtedly unfamiliar to the general population. Nevertheless, to the two million American asthmatics whose illness costs them an average of 12 to 30 percent of the total family income, any new revelation on the possible causes of their affliction is a breath of life.

If the association between asthma and intestinal worms seems peculiar, the origin of the story is even stranger. The opening chapter was set, not in Nigeria or Nicaragua or some similar tropical country where an intestinal zoo is so common as to be a way of life, but in Niagara Falls, Ontario.

Over the years a doctor there named Tullis noted what seemed to be an extraordinary number of asthmatic cases, 14 percent of all nontubercular patients, seeking medical attention at the Niagara Peninsula Sanatorium. He also found that the usual provocative agents (allergins), such as pollen and house dust mites, did not appear to be the cause of asthma in the majority of those patients. With remarkable intuitiveness, considering Ontario's nontropical geography, Tullis decided to look for intestinal parasites in his patients. After careful examination of fecal specimens, he found the sign of the worm—their characteristic eggs—in 198 of 201 patients with bronchial asthma, while all of his allergy-free controls were "clean."

In 1971, Tullis published his findings in the *New England Journal of Medicine.* The worm-asthma hypothesis was quick to excite the interest of the biomedical community, and other studies were undertaken in an attempt to confirm Tullis's assertion. Confirmation was not forthcoming. From Boston and from the Mayo Clinic in Rochester, Minnesota, investigators failed to find a single worm in any of their asthmatic patients.

The failure to confirm Tullis's findings didn't really dismiss the worm as an allergin. The argument was that while Boston, Massachusetts, and Rochester, Minnesota, might be worm free, Niagara Falls, Ontario, because of its location, was not.

Lake Erie's Canadian bathing beaches are near the Welland Canal, which connects that lake to Lake Ontario. Through this canal passes a lively international maritime commerce manned, in some cases, by tropical seamen and, as stowaways, their intestinal parasites. The sewage discharge from these boats is thought to float to the beaches where the infectious worm eggs are washed ashore. Under these unusual circumstances, the local population is believed to be exposed to that ubiquitous tropical triad of parasites, the roundworm (*Ascaris lumbricoides*), the whipworm (*Trichuris trichiura*), and the hookworm (*Necator americanus* and *Ancylostoma duodenale*).

While the Niagara Falls debate was taking place, Carolyn Coker Huntley, a professor of pediatrics at North Carolina's Bowman Gray School of Medicine, proposed that still another allergin, the dog roundworm, *Toxocara canis,* was of equal, if not greater, importance in provoking asthma. *T. canis* is not sufficiently adapted to complete its development to sexual maturity in a human host. However, when embryonated eggs containing the minute infective larvae are accidentally ingested, as can happen when children grub about in contaminated soil, the larvae hatch and remain for years in the body tissues without maturing further. The infection, known as visceral larval migrans (VLM), is characterized by an enlarged liver and serious lesions of the eye if the larvae invade that organ. Huntley observed that for many of her patients with VLM, the initial symptom was an asthmalike condition, and she suggested that there might be a considerable number of individuals in whom VLM manifests itself mainly as a pulmonary disease. This was an interesting idea, but since it was based solely on clinical insights (it is almost impossible to recover the microscopic larvae within the body), it remained a theory without experimental foundation.

The Huntley hypothesis was of particular interest in Hawaii because the islands have the highest prevalence of asthma in the United States. Could some of the "Waikiki wheeze" be due to parasitic dog worms? Again we were confronted with the problem of making a direct, parasitologic diagnosis, and administering a provocative test dose of worm eggs to asthma patients was clearly unacceptable. However, parasites, whether they be worms, bacteria, or viruses, leave a distinctive spoor, the specific antibody the host produces in response to their intrusion.

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Using an exquisitely sensitive radioactive technique to measure specific allergy antibodies (given the scientific shorthand designation of IgE), we tested the serum of asthmatic children to determine whether they had antibody specific for dog worms. We expected that a few of the patients in our study would be serologically positive but were startled to find that 45 percent of the group had antibody to these parasites (less than 10 percent of the nonasthmatic control group had "worm" IgE). The immunologic trail not only led to *Toxocara canis* but it revealed that the mosquito-borne parasite of dogs, *Dirofilaria immitis,* was also involved.

*D. immitis,* better known to dog owners as heartworm, is an important cause of debilitating disease in canines. Only recently have we become aware of its potential threat to humans, and the parasite is now considered to be an emerging zoonosis, that is, an infection transmissible from animals to humans. The life cycle of *D. immitis* is typical of filarial, or threadlike, worms. Birthed in dog tissues, the larvae circulate in the blood until picked up by a mosquito in which they mature into infective stage larvae. The infected mosquitoes often bite humans and dogs indiscriminately, inoculating either host with their charge of infective larvae.

Like the dog roundworm, heartworm is incapable of completing its normal life cycle in humans. Instead it migrates to the lungs where it produces a lesion that gives an X-ray picture similar to that of a malignant tumor. That is the extent, so far, of the clinical knowledge of human dirofilariasis, but as with many other "new" diseases, there are undoubtedly several additional manifestations, including allergic hypersensitivity, that have not as yet been identified.

The worm-asthma hypothesis provoked the interest of physicians and biomedical scientists working in the tropics. If the few Niagara Falls worms could cause so much asthma, the allergic potential of the staggering worm burden of the world's warm regions must be enormous. If the theory were true, the globe's girdle between the Tropics of Cancer and Capricorn should be literally wracked by an enormous asthmatic spasm. Asthma had never been considered a significant medical problem in the tropics, where the multitude of regional diseases, many of them life threatening, is so great that a "mere" allergy might have been overlooked.

Contrary to expectation, the epidemiological studies carried out in the tropics indicated that not only were intestinal worm parasites *not* the cause of asthma, they actually *prevented* it. One investigator searched for asthma in The Gambia, the narrow, coastal West African nation that extends inland partway through Senegal. He found that asthma was virtually absent from the rural population but common in city dwellers. The countryside encourages a personal crop of intestinal parasites that come from the soil, while the city environment is relatively protective against these infections. Basing his hypothesis on known immunological phenomena associated with worms, this researcher attributed the absence of asthma in the rural population to the plethora of worms. A group of workers in the Department of Medicine at Ahmadu Bello University in Nigeria came to essentially the same conclusion. Finally, there was an account from a self-infected parasitologist in England. In a letter to the *Lancet,* this specialist wrote that he had had severe hay fever each summer since the age of eight. Then, in the course of one of his experiments, he had need of a regular supply of hookworm larvae and decided to become his own biological supply house. For two years he periodically subjected himself to infective-stage hookworm larvae and during those years he remained completely free from hay fever.

Ultimately, the pro-wormists and anti-wormists were joined by the no-wormists. Investigations carried out in Tanzania and the Gaza Strip failed to show any relationship of intestinal parasites to asthma. Asthma was found to be as prevalent among city dwellers as among rural agriculturists. There were as many asthmatics with worms as nonasthmatics with worms.

So now we have three propositions. One is that parasitic worms cause asthma. Another is that parasitic worms prevent asthma. And the third is that parasitic worms have nothing whatsoever to do with asthma. Which proposal is correct? Probably under certain conditions and in certain individuals any one of the three relationships is possible. The logic of this confusion can best be understood if we first examine the nature of allergy.

Allergy is a kind of immune response. The body's immune system screens and rejects foreign substances, be they parasites, microbial pathogens, or someone else's heart. The system is complex beyond belief, and almost beyond understanding, but essentially it consists of two cooperating agencies: a cell-mediated, or cellular, arm and a humoral, or fluid, arm. The cell-mediated arm is staffed by macrophages—large cells that ingest and digest pathogens and other particulate matter—and by other cells that send chemical signals for the macrophages to assemble where needed. The humoral arm secretes proteins—the antibodies found principally in blood serum—when confronted by a pathogen or other antigenic substance. The antibodies have a specific configuration that allows them to combine with the antigen to render it innocuous.

Without the development of an immune system, animals, including humans, undoubtedly could not have evolved or survived. The ubiquitous attack of a huge array of invading microbes probably would have precluded survival. However, the IgE "allergy antibody" acts somewhat differently from other antibodies and seems to make no adaptive sense. Unlike other classes of immunoglobulins, IgE does not combine directly with the antigen against which it was specifically elaborated. Instead, one end of the antibody molecule fixes to special receptor sites on the surface membranes of certain types of white blood cells and cells present in connective tissue. All these cells are, in a sense, packets of potential dynamite. They manufacture and store histamine and other substances whose action on blood vessels and other tissues is manifested by the symptoms of the allergic state. Fortunately, these substances normally remain within their cellular storehouses. (In an earlier article, "Harmonious Parasites," *Natural History,* September 1977, I described how they are released when the cell-fixed IgE molecules become bridged at their exposed ends by the allergin.)

That is the how of allergy. The why is still not completely understood, although both genetic predisposition and the nature of the provoking allergin play a role. Five classes of immunoglobulins have been recognized—IgG, IgM, IgA, IgE, and IgD. When an individual is exposed to an antigen, a group of specialized cells, the plasma cells, are switched on, begin to proliferate, and then manufacture and se-

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crete one of the five classes of antibody that will specifically combine with the antigen. In most humans this will be the IgM and IgG classes but some individuals may switch on other classes. In allergic individuals the genetically directed response is, primarily, to switch on a clone of IgE-secreting plasma cells. Thus, allergy is an inherited factor but only in the broad sense. For example, a person who is allergic to fish will not pass on that particular allergy but will pass on the tendency to become allergic. The allergin that plagues the parent may be very different from the one that plagues the child.

The chemical and structural acrobatics that turn an antigen into an allergin have not, as yet, been identified. We know that certain antigens are more likely to switch on an IgE response than other antigens. Pollens and house dust mites, for example, are more allergenic than bacteria or viruses. But of all the allergins, the parasitic worms are the most powerful in stimulating IgE production.

In normal individuals, the serum IgE concentration is less than 200 units per milliliter; in hypersensitive individuals with pollen allergy it is some 400 to 600 units; in those with worm infections it usually ranges from 1,000 to 5,000 units. Some of this IgE is specific antibody for the worm, some of it seems to be nonspecific "rubbish" antibody, and some of it may be directed against completely different allergins. Experiments have shown that worm infections can potentiate IgE antibody responses against completely unrelated allergins. If these observations hold true for humans, an individual with worms could be more hypersensitive to pollen, for example, than an individual without worms. To make matters even more confusing, other experiments have shown that some parasitic infections suppress immune responses to unrelated antigens. In that case, our wormy individual would be less sensitive to pollen than his "clean" counterpart.

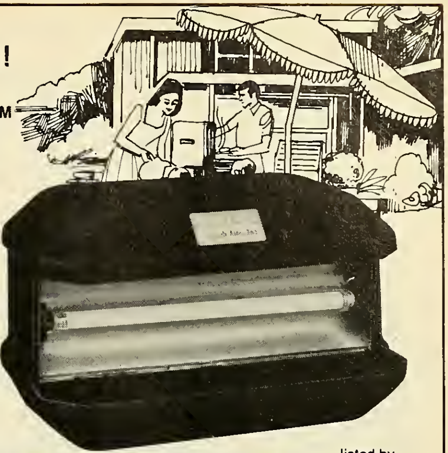
Within this maze of conflicting experimental observations may lie the answer to the worm-asthma controversy. It is probably a matter of degree. A few worms in "immunologic virgins," such as the patients in Niagara Falls, may stimulate production of specific IgE antibody to the worms and/or potentiate IgE elaboration to other allergins. A large number of worms and constant reinfection, such as occurs under the unsanitary conditions of much of the world's warm and wormy regions, would probably stimulate nonspecific, as well as specific, IgE and also suppress the immune responses to other antigens. The large amount of nonspecific rubbish antibody in those with worm infections would act as "blocking" antibody, preventing the release of histamine and inhibiting allergic asthma. Worm loads of an intermediate magnitude might have no effect on the inhibition or production of asthma and the other manifestations of allergy. Other factors, such as the kind of worms endemic to a particular region and the immunogenetic character of the population, may also be imposed upon this speculative scenario.

I said earlier that the immune response that causes the allergic state made no adaptive sense. What benefit can be gained from hay fever, food allergy, or asthma? But unless Darwin is to be denied, at some time in mammalian evolutionary development the allergic reaction must have had selective advantage. It may have begun, for instance, to give the intestinal worm an "asthmatic attack."

All mammalian species have unwelcome intestinal worms embedded in the lining of their intestines, and it has now been shown that IgE plays an important role in getting rid of them. The IgE becomes fixed to most cells in the intestinal connective tissues. These cells localized about the worm discharge their pockets of histamine when the parasite's antigens, probably their metabolic products, couple to the antibody. The histamine and other pharmacologically active substances act on the parasite to give it an "allergic spasm" that causes it to vacate its site and be swept away in the feces.

Thus when that first mutant plasma cell tentatively produced an antibody molecule that became fixed to host target cells, it may have served man's distant ancestors as an agent to destroy or expel worms. Unfortunately, what may have started as a good thing became a disaster, and eventually, there developed an IgE plasma cell population that recognized and responded to all the allergins that now bedevil us. However, relief from allergy may yet be found to reside in the creature that could well have started it all—the worm.

*Robert S. Desowitz teaches tropical medicine at the University of Hawaii.*



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# The Belt of an Asteroid

*An extraterrestrial object may have brought mass extinction on the earth 65 million years ago*

**by Stephen Jay Gould**

The ten plagues of Moses are the archetypal disasters of Western thought. I am therefore not surprised that popular explanations for major catastrophes in the history of life have tended to follow their scenarios in spirit. The most famous (although not the most profound) mass extinction occurred some sixty-five million years ago at the close of the Cretaceous period. All surviving dinosaurs died, as did their giant cousins in the air (pterosaurs) and in the seas (ichthyosaurs, plesiosaurs, mosasaurs). The oceanic plankton virtually disappeared with dramatic suddenness at a boundary that geologists call the plankton line. Several major groups of marine invertebrates perished, including all ammonites and the curious rudistid clams, which looked like corals and formed reefs.

Evidence for the cause of this great dying is so sparse that speculation receives free rein (and reign). The primal scenarios of Moses force themselves upon us. Theories of pandemics run wild recall the murrain that killed Pharaoh's cattle and the boils "breaking forth upon man, and upon beast." Poisoning of the oceans by copper washed in from the land or by a lens of fresh water spreading out from a fractured arctic lake reminds us of the Nile turned to blood—"and the fish that were in the river died; and the river stank. . . ." Dramatic change of climate conjures up the great hailstorm that fell "upon man, and upon beast, and upon every herb of the field. . . ." Voracious predators and parasitic pestilences have their counterpart in the successive deluges of frogs, lice, flies, and locusts that Pharaoh endured. Even the slaying of the children recalls the common (if rather silly) speculation about primitive mammals happily munching on dinosaur eggs. The only Mosaic plague that has not been well represented among the catalog of late Cretaceous disasters is the great darkness that blanketed Egypt for three days—"even darkness which might be felt."

I am happy to report that this serious omission has now been rectified. I am even more delighted to report that this latest entry has a basis in evidence of an entirely new sort. It has made legitimate, for the first time, a large class of explanations heretofore characterized by perfect plausibility in theory combined with utter lack of confirming evidence—extraterrestrial events. Would you believe an asteroid so big that it hit the earth and threw up a dust cloud thick enough to block photosynthesis entirely for a decade? Pharaoh almost tossed in the towel after a mere three days. But let me bypass the asteroid for a few paragraphs to discuss some ground rules and principles about mass extinction.

The major theories of mass extinction can be divided into two groups according to their stance on each of two issues: *source* (within or outside the earth) and *rate* (truly sudden or only relatively rapid). The earth itself is a source for some proposed causes, either by such physical mechanisms as changing climates engendered by shifting continents, or such biological factors as disease, competition, and collapse of food chains. Extraterrestrial hypotheses have ranged from variation in solar output, to cosmic radiation from nearby supernovae, to impacts of various bodies. Some notions of rate posit not merely a relatively rapid blip in the vastness of time but true cataclysms, disasters on the short scale of a human life—extraterrestrial impact theories, for example. Other determinants of mass extinction would be too slow to note during a human lifetime, but do their work in thousands or even millions of years, against a backdrop of billions. Most of these implicate changes of climate, including drops in sea level and the growth of glaciers.

Geologists, like all folks, have their prejudices. They prefer causes emanating from their own domain, the earth. Since Lyell's day they have been trained to view major change as the accumulation of small inputs based on processes that can be observed in the relatively calm geologic present. These preferences have combined to give cataclysmic extraterrestrial theories a poor shake. Yet I think that few geologists would deem it inherently impossible, or even unlikely, that the earth might have suffered grievous cosmic insults at very infrequent intervals during its vast history.

But there is another reason, better than traditional prejudice, for the low esteem of extraterrestrial catastrophes. Geologists have not known, even in principle, any way to obtain direct evidence for them. What direct sign would a supernova or pronounced

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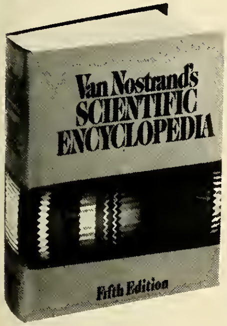
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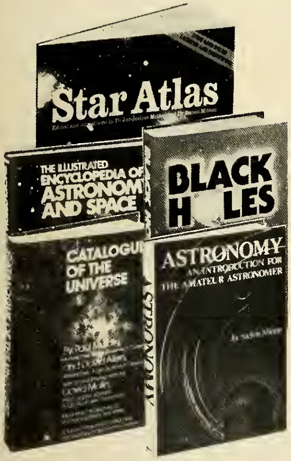
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variation in solar intensity impose upon the earth? Indeed, the traditional argument for cosmic ray zapping by supernovae relies upon total lack of evidence—the fact of mass extinction accompanied by no recognized geologic agent that might have caused it! Thus, many geologists, including myself, have long found themselves in the uncomfortable position of viewing extraterrestrial catastrophes as inherently plausible but rooting strongly against them because we knew no way of obtaining evidence for such catastrophes even if they had occurred. The asteroidal theory has changed all that.

The facts of the Cretaceous extinction exert constraints upon the types of theories we may propose to explain them. We know, for example, that the extinctions occurred throughout the world and in all major environments—land, air, and sea. This alone virtually invalidates the entire panoply of popular theories that would attribute the extinction of dinosaurs to a cause related only to their supposed lumbering inefficiency—mammals eating their eggs, flowering plants pumping too much oxygen into the atmosphere, hyperpituitarism arising from large size and leading to sterility. Any harebrained idea can win notoriety in a context of such public fascination. Someone once proposed in all seriousness that male dinosaurs simply became too heavy to mount their partners for sexual intercourse, although I could never figure why little *Velociraptor* became extinct along with its giant cousins (not to mention what the giant brontosaurs were doing during the 100 million years or so of their success). The primary fact of dinosaur extinction is its timing as part of a global mass dying. We need a general theory, not a set of facile speculations for single groups.

We also know that the Cretaceous extinction included some aspects of geologically sudden death and others of more lingering demise. For some groups, the final phase of the Cretaceous seems to have acted more as a *coup de grâce* than an exterminating angel. Dinosaurs and ammonites had been in decline for millions of years. The dinosaur fauna of the latest Cretaceous did not include one of everything around a waterhole (as the multicolor chart on my kid's wall suggests), but a sharply reduced assemblage consisting largely of *Tyrannosaurus, Triceratops*, and a few smaller creatures. We can also correlate these slower declines with some geologic events often implicated in extinctions (but please remember that correlation need not imply cause). Sea level declined steadily throughout the late Cretaceous; the continuous seaway that had split North America in two, running from Alaska to the Gulf of Mexico, withdrew gradually in both directions. As sea level dropped and continents grew in height and extent, temperatures began a general decline that continued throughout the next seventy million years, culminating in our recent (and still uncompleted) cycle of glacial ages.

Falling sea level has accompanied nearly every mass extinction that the earth has suffered; this correlation is about the only aspect of mass extinction that evokes general agreement among geologists. Its negative effect upon biological diversity also makes sense—for falling seas drained the extensive but shallow continental shelves, thereby removing a large chunk of living space from the domain of shallow-water invertebrates, the dominant fauna of our fossil record. Harsher conditions then spread across the land as the increasingly erratic and generally colder weather of a more "continental" earth prevailed. No dinosaur may ever have eaten an ammonite (although the giant mosasaurs, overgrown varanid lizards, did), but the coordinated decline of both groups may be causally related to dropping sea levels.

Yet we cannot attribute the entire Cretaceous extinction to a gradually deteriorating climate. Something more dramatic must have happened, as the plankton line testifies. Perhaps this dramatic cause gained greatly in effect because more groups than usual were in decline and therefore susceptible to a *coup de grâce*. In this sense, any complete theory of the Cretaceous extinction will be a complex combination of a dramatic end superimposed upon a general deterioration. On the other hand, a fair percentage of groups are always in decline, and catastrophes will always administer the *coup de grâce* to something. Extinction is no shame, but rather the ultimate fate of all major groups; dinosaurs and ammonites had done better than most.

In any case, geologic evidence constrains us to look for a cause that is worldwide in effect, able to exterminate groups in all major habitats, and geologically sudden for at least some of its results. Which brings me back to asteroids.

The asteroidal theory, like so many interesting hypotheses in science, had its root in a study with markedly different aims (you cannot actively look for the utterly unexpected). A team headed by Luis and Walter Alvarez at Berkeley, California, thought that they might use the amount of iridium in sediments as an indicator of their depositional rate. Iridium, a rare metallic element of the platinum group, is one to ten thousand times more abundant in asteroids and meteorites than in the earth's crust and upper mantle. (Since both the earth and meteorites congealed from the same source, we must assume that the earth as a whole contains as high a percentage of iridium as the meteorites.) But the earth melted and differentiated, and such heavy, unreactive elements as iridium sank into the inaccessible central core. The smaller bodies that form meteorites and asteroids never differentiated and therefore maintain iridium in its primeval abundance. Hence, most iridium in the earth's sediments comes from extraterrestrial sources. Working with the common assumption that meteorites and cosmic dust intrude on the earth as a fairly constant rain, the Alvarezes reasoned that sediments high in iridium must have formed slowly since relatively less earth-based debris had accumulated to dilute the cosmic influx.

But the Alvarezes were not prepared for the anomalously high concentrations of iridium that they found in two places: in the Umbrian Apennines of Italy and near Copenhagen. Iridium levels were 30 times higher than average in Italy and 160 times higher in Denmark. Moreover, an analysis of twenty-seven other elements in the Italian sample showed that none departed by more than a factor of 2 from "average behavior" in ordinary sediments. The anomaly involves iridium alone.

The Alvarezes wondered if they could apply the style of explanation they had originally favored: could sedimentation have been slow enough in these two places to yield such a high concentration of iridium from the normal cosmic rain alone. But they could find no evidence or even think of any reason for believing that these sediments had formed during a virtual shut-off of normal, depositional processes in the ocean. Instead, they were forced to reverse their perspective: sedimentation had been more or less normal; the iridium represented a genuine cosmic influx of unusual amount, not an undiluted gentle rain. The Alvarezes had another outstandingly good reason to favor such a reversal. Both samples came from thin clays deposited at the very top of the Cretaceous—coincident with the great extinction.

But what extraterrestrial source might both have produced the iridium and acted as a cause of the great extinction. The Alvarezes looked first to that venerable old standby of cosmic theories—the supernova that exploded near the earth and zapped our planet with so much cosmic radiation that many creatures mutated themselves out of existence. Yet, after flirting with the idea (partly in public) for a while, they dropped it—to my great delight, for it has never made any biological sense to me, despite its almost knee-jerk popularity in the "disaster literature." Radiation increases the mutation rate and yields a population with more variation. But more variation per se leads neither to extinction by prevalence of monstrosities nor to unusually rapid rates of evolution, because evolutionary tempos seem to be controlled by a different force—natural selection. Ordinary populations possess enough variation (without external goosing) to permit evolutionary rates so rapid that they appear instantaneous in geologic perspective. Mutation rates so high that they kill animals directly (not through the passage of defective genes to offspring) require supernovae too close to our sun to be plausible, given the spacing of stars in our part of the galaxy.

The Alvarezes now cite three reasons for rejecting a supernova:

1. A supernova would also have produced a high concentration of an ion of plutonium ($^{244}$Pu), yet the Italian and Danish clays contain levels of this ion ten times below the predicted value for a supernova..
2. Iridium occurs as two common isotopes ($^{191}$Ir and $^{193}$Ir). Since all the objects of our solar system had a common origin, the ratio of these two isotopes should be the same in meteorites and in the small amount of iridium indigenous to the earth's crust. Iridium formed in other stars might exhibit a different ratio. The ratio in the anomalous Italian and Danish samples matches that of the earth's indigenous iridium and probably came from our solar system.
3. In order to zap the earth with as much iridium as the Italian and Danish samples contain, the exploding star would have to be so close to our sun that the probability of such an event becomes too small to be believed.

Since the ratio of iridium ions led the Alvarezes to seek a source within our own solar system, they turned to objects that might hit the earth with reasonable probability and do sufficient damage. Most asteroids orbit the sun in the large space between Mars and Jupiter, but a few have more erratic orbits, and some, called Apollo objects, cross the earth's orbit in their wanderings. Since the asteroid Apollo was discovered in 1933, twenty-seven others that cross the earth's orbit have been

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sighted. Astronomers discover an average of four more each year, while two independent estimates yield about 700 for the probable number of Apollo asteroids more than six-tenths of a mile (one kilometer) in diameter. The Alvarezes conclude that occasional collisions between Apollo asteroids and the earth are inevitable.

In short, their current scenario for the Cretaceous extinction calls upon the impact of an Apollo asteroid approximately six miles in diameter. They calculate that such an object would have produced a crater about 100 miles in diameter and injected enough dust into the atmosphere both from its own pulverization and by dismemberment of the earth around it to have made our entire planet as dark as Egypt during Pharaoh's ordeal. Photosynthesis might have been completely suppressed for a decade or so, leading to immediate death of the photosynthetic plankton (with their short generation time measured in weeks) and a subsequent collapse of the oceanic food chain based upon them. Most species of large terrestrial plants might have survived through the dormancy of their seeds, but the parental plants themselves would have died and taken their dinosaur herbivores with them. The Alvarezes calculate that Apollo asteroids of this size could have hit the earth with sufficient frequency to cause the six or so major extinctions that have punctuated the history of life since the inception of an adequate fossil record some 600 million years ago.

This scenario is not devoid of major problems. I am most disturbed by the special pleading required to make the pattern of extinctions come out right. I can buy the oceanic argument, but balk at the Alvarezes' attempt to explain why three terrestrial groups got through the great darkness relatively unscathed: plants, small vertebrates (mammals and birds), and nearshore vertebrates. In a classic case of eating and having their cake, they permit mammals to survive by eating seeds, yet call upon those very seeds to save the plant species that engendered them. Their explanation for nearshore vertebrates is grounded more in hope than in logic: survival "may be due to their ability to utilize food chains based on nutrients derived from decaying land plants carried by rivers to the shallow seas."

The Alvarezes are also suffering from too much of a good thing, for levels of iridium in the Danish sample are embarrassingly high. They calculate that average asteroidal iridium mixed with about 100 times its mass of earth material (the amount needed to conjure up the great dust cloud) should increase mean iridium levels in sediments by only about one-tenth the Danish amount. The Italian sample runs closer to expectations.

Other problems may be in store. One uncertain study argues, from the fine stratigraphy of magnetic reversals, that the plankton line is not coincident with dinosaur extinctions—a small effect for the more leisurely concept of geologic suddenness (which might span many thousand years), but potentially fatal to the Alvarezes requirement for true simultaneity. I feel that the Alvarezes assume the proper attitude toward this report: they acknowledge it forthrightly, note its uncertainties, admit that its later confirmation would greatly weaken or destroy their hypothesis, and then predict—on the basis of their theory—that the report is both probably in error and greatly in need of more study.

But I care little whether the asteroidal scenario itself is correct. The remarkable aspect of the Alvarezes' work—the part that has produced buzzing excitement among all my colleagues, rather than the ho-hum that generally accompanies yet another vain speculation—lies in their raw data on enhanced iridium at the very top of the Cretaceous in two separated places. For the first time we now have the hope (indeed the expectation) that evidence for extraterrestrial causes of mass extinction might exist in the geologic record. The old paradox that we must root against such plausible theories because we know no way to obtain evidence for them has disappeared.

When I started my career as a paleontologist, I used to argue that mass extinctions might be rip-roaring fun to discuss but relatively unimportant for the ultimate disposition of life and its history. I was then caught up in some common prejudices about inherent, stately progress as a hallmark of life's history. The mass extinctions, I thought, might disrupt the process severely, setting the clock of progress far back. But time (to a geologist) is not a severe constraint;

life would recover, moving on (and past) as before.

I can't think of any other idea I once held (after age five) that I now regard as so foolish (except the thought that the N.Y. Giants might catch the Brooklyn Dodgers in 1951, which they did—thanks again, Bobby Thomson). The history of life has some weak empirical tendencies, but it is not going anywhere intrinsically. Mass extinctions do not simply reset the clock; they create the pattern. They wipe out groups that might have prevailed for countless millenniums to come and create ecological opportunities for others that might never have gained a footing. And they do their damage largely without regard to perfection of adaptation (the most gorgeously designed photosynthetic plankter could not survive a great darkness, while some marginal competitor might squeak through and become a progenitor of the next dominant group).

Who knows? Without the great Cretaceous extinction, dinosaurs might have rallied and still dominate the earth (they had already lived for far longer than the sixty-five million years since their demise). Mammals might still be a small group of ratlike creatures casting about for an occasional bit of protein in a triceratopsian egg.

Among the Cretaceous mammals that witnessed the great event, we know a single primate named *Purgatorius*. It may not have been the only member of our order, but there probably weren't many of us back then. Suppose that *Purgatorius* hadn't pulled through—and remember, it probably owed its continuation to luck or to adaptations not related to features we value in primates because we have capitalized upon them. Primates would not have reevolved. A giraffe on the plains might now be surveying the creation from on high and smugly regarding itself as the finest of all God's creatures. Our current existence is an extended function of such enormous improbabilities. We may owe our evolution, in large part, to the great Cretaceous dying that cleared a path, yet permitted our ancestor's life to tread upon it. That asteroid may well have been the sine qua non of our existence.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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# The Pocket Gopher Mound Probe

*Their architecture riddles the landscape, but the builders rarely come into view*

**by David S. Lee**

**photographs by Raymond A. Mendez**

People who live in pocket gopher country know well the conspicuous mounds of sandy soil made by the underground rodent. But few have ever seen the little animal, for the pocket gopher spends practically its entire life in a self-constructed burrow system, rarely venturing aboveground.

I was reminded of the pocket gopher's low public profile one summer while trapping research specimens near Gainesville, Florida. Curious about my digging activities, people would sometimes gather, and when told the object of my search, they were eager to see the subterranean animal. The usual comment was that even though they had seen the mounds for most of their lives, they had never seen the animal that made them. Most onlookers, surprised at the gopher's appearance, remarked that it resembled a rat. Indeed, its appearance must startle people who for generations have called pocket gophers "salamanders," and who likely conjured up an interesting bestiary in their attempts to visualize them.

The origin of the name salamander as applied to the pocket gopher is not clear. One possibility is that it is a corruption of "sandy-mounder," a name derived from the telltale piles of soil displaced from the animal's burrow system. Salamander is apparently reserved for the southeastern pocket gopher, *Geomys pinetis*, since its western counterparts are simply called gophers. In the Southeast, however, the name gopher is usually reserved for a reptile—the gopher tortoise. These tortoises also make burrows in the ground, and they frequent the same habitat, within a similar geographical range, as the pocket gopher. The need to distinguish these two animals may have resulted in the regional name salamander.

The southeastern pocket gopher is physiologically and behaviorally tied to a narrow association of fire-maintained xeric plant communities. The association with fire is another possible origin of the name salamander, which means "fire animal," for after a ground fire, the mounds of soil are not only more conspicuous but often more numerous. Thus, the local name could have the same derivation as that of the fire-loving salamanders of European folklore.

Pocket gophers are found throughout much of the southern United States and Central America, where more than 300 forms have been described. They achieve their greatest diversity in the southwestern United States; a smaller number of species and subspecies are known from areas of the West Coast, the Midwest, and the Southeast. All pocket gophers are medium-sized rodents (6.5 to 8 inches in body length) with fur-lined cheek pouches in which they carry food. These external pouches, or pockets, extend from beside the mouth down along the sides of the neck. The animal's large, exposed incisors are used as picks in burrowing. Dirt and sand do not get into the mouth, however, because the lips close behind the front teeth. The body is thickset and strong; the skin very loose and covered with short, soft hair. Although generally rodentlike in appearance, a pocket gopher looks strikingly out of proportion because of its enlarged head, shoulders, front legs, and claws. Its ears and eyes, on the other hand, are disproportionately small.

One of the most interesting aspects of the natural history of pocket gophers is their adaptation to an underground life style. Although the southeastern pocket gopher uses a resource (roots and rhizomes) not shared with any other local vertebrate, lives in a self-contained world of moderated temperature, and is fairly free of predators, the adaptations needed for a subterranean life are many. A low metabolic rate and the ability to obtain moisture from plant material enable gophers to compensate for a lack of free water in their burrow environment. Marked seasonal changes in food storage behavior, burrowing activity, and metabolic rate help gophers cope with annual fluctuations in temperature and food availability. Even superficial inventories of fresh mounds indicate considerable variations in seasonal activity, with the greatest number of new mounds appearing in the spring and the fewest during prolonged dry or cold periods in summer, fall, and winter.

Because the sealed tunnel system limits air exchange with the surface, pocket gophers must also be adapted to living in an atmosphere low in oxy-

*Large shoulders, front legs, and claws are adaptations for burrowing that enable the southeastern pocket gopher to construct extensive tunnel systems. Its eyes and ears are relatively small.*

*The digging activity of gophers has a strong effect on soil composition. Noncapillary porosity, organic matter, phosphorus, and nitrogen are higher in areas where the rodents are present.*

gen and high in carbon dioxide. Studies done by Perran Ross when he was a student at the University of Florida show a marked tolerance to high concentrations of carbon dioxide in this species. Ross also concluded that lower metabolic rates help limit oxygen requirements of pocket gophers and reduce their respiratory water loss. The high relative humidity of their closed environment may make regulation of body temperature by evaporative cooling a problem; perhaps their naked tail and feet aid in the dissipation of excess body heat.

The closed burrow system provides effective protection from predators, and pocket gophers have a relatively low mortality rate. This situation is balanced by an equally low reproductive rate. Studies suggest that southeastern pocket gopher males are sexually active all year and that females have at least two annual peaks of reproductive activity; yet more than 90 percent of all animals trapped were adults or subadults. The young of the year made up less than 10 percent of the sample. Embryo counts averaged only 1.5 per pregnant female. Such limited reproductive potential, while unusual for a small rodent, is not so surprising when one considers the pocket gopher's low vulnerability to predation.

With such a solitary life style within a self-contained burrow system, how does one pocket gopher find another of the opposite sex in order to mate? It is possible that males spend some time aboveground in search of females, and they may locate females in estrus by odor. Exposure to predators might account for a decrease in the percentage of adult males in the population (40 percent) compared with the percentage of males in the juvenile population (50 percent). Nevertheless, most searching takes place below ground. Males habitually construct long, straight tunnels, which greatly increase their chances of encountering the randomly directed burrows of females. On trapping expeditions I have occasionally used this bit of knowledge to wager with unsuspecting students as to the gender of the occupant of a particular burrow. One romantic male we encountered had tunneled in a perfectly straight line for more than 150 yards. When we captured him he was at the front line extending his tunnel. After mating, the males and females block off their tunnels to each other.

Due to the conspicuous mounds, the geographical and ecological distributions of pocket gophers can be easily studied. Mound inventories along road shoulders and other open habitats are readily made from a car. Thus, large tracts can be surveyed intensively and in a short time, with roads serving as convenient transects. By recording locations of colonies on county road maps, I was able to compare them with detailed regional soil and vegetation maps. In areas that have not been modified by man, I found that southeastern pocket gophers occur most frequently in upland scrub and sandhill plant communities that are maintained in a subclimax stage of ecological succession. In most cases fire caused by electrical storms serves as the policing agent, preventing dense understories of vegetation from becoming established. When fire is an almost annual occurrence, only the herbaceous ground cover burns, and the open, parklike stands of such fire-resistant trees as longleaf pine and turkey oak are not seriously damaged. After several years without fire, enough herbaceous growth accumulates to support fires hot enough to kill the turkey oaks and intermediate-sized pines. Both types of fire are important in maintaining the open-canopied, herb-dominated savanna. Pocket gophers are not adversely affected by these fires; in fact, they are dependent upon them for survival since the fires maintain open areas where the gophers can burrow more freely and feed on rhizomes.

Because of modern land-use practices, sandhill and scrub habitats are rapidly disappearing. Yet in many places the pocket gopher seems to be holding its own. Road shoulders, power line rights of way, and railroad embankments provide adequate habitat as well as avenues of dispersal across unfavorable areas. During a period of several years I watched a population of pocket gophers expand its territory along the road shoulder of a central Florida interstate highway. From here the animals had access to a number of disturbed habitats—lawns, orchards, and golf courses—that suited their needs. Artificially maintained habitats may provide a higher-quality environment than natural communities and may be more attractive to colonizing individuals. On the other hand, some peripheral populations have disappeared in the last several decades.

The late H.B. Sherman was very interested in southeastern pocket gophers, and during the 1930s and 1940s he collected series of animals from many areas. Since many of his collecting sites no longer support extant populations, Sherman's collections, now at the Florida State Museum, are perhaps our best documentation of the historical range of the pocket gopher in the Southeast. Sherman's studies indicate that there are four distinct species in the area, although two, *G. colonus* and *G. cumberlandius*, are confined to a small area in coastal Georgia, and another, *G. fontanelus*, is known only from the city of Savannah. *G. pinetis* occurs throughout the remainder of the coastal plain of Georgia, much of Alabama, and north and central Florida. Within this area its distribution is not uniform. Because of the taxonomic work of Sherman and others, five subspecies are recognized. These appear to have had their origins during periods of high sea levels when populations were partly or entirely isolated. During the Pleistocene, glacial ice covered major portions of North America, and sea levels receded, exposing large areas of land. Throughout the area vast savannas developed. Most of the larger animals that lived on the savannas died out toward the end of the Pleistocene, but some, such as llamas, peccaries, and tapirs, extended their ranges into South America as their north temperate populations were being extirpated.

Several years ago, while examining a rich Pleistocene fossil bed near Gainesville, Florida, paleontologist David Webb of the Florida State Museum and I found remains not only of ground sloths, camels, giant tortoises, hyenas, and giant cats but also of smaller fauna. Webb showed me fossil fragments of harvest mice, rabbits, cotton rats, rice rats, and pocket gophers. The gopher fossils dated back 7,000 to 2 million years, yet were similar in all measurements to recent *G. pinetis.* At the same time, they cannot be separated with any precision from species from the Southwest.

Based on patterns of distribution, the southeastern pocket gopher is of western origin. Many other species found in the same plant communities occupied by southeastern pocket gophers also originated in the West. The American whip scorpion, eastern diamondback rattlesnake, indigo snake, gopher tortoise, scrub jay, and burrowing owl are but a few of the "western" species found in the Southeast. Most are found in close association with sandhill and scrub habitats, some exclusively so. Many plants with similar distributional histories combine with the fauna to form a "western" landscape.

The fossil record of pocket gophers is not the only indicator of a long history in the Southeast. Perhaps just as revealing is the large assemblage of animals that has evolved within the protective confines of the pocket gopher's burrow system. The burrow is an environment in which exposed rootlets, stores of roots, bulbs, and rhizomes, and the pocket gopher's grass nest furnish nourishment for many insects and other arthropods. Forty years ago two entomologists from the University of Florida, T.H. Hubbell and C.C. Goff, investigated the commensal arthropods of pocket gopher burrows. Of the sixty species they found living in the passageways, at least fifteen were highly modified for subterranean life and have never been found anywhere except in pocket gopher burrows. One of the most common inhabitants is a blind camel cricket, *Typhloceuthophilus floridanus.* In appearance, this unpigmented insect with its elongated appendages is as impressive as its name. Like many inhabitants of pocket gopher burrows, the camel cricket appears to be a scavenger, feeding on fecal material and organic debris. The pocket gopher itself is host to many specialized internal and external parasites, most of which occur exclusively in or on *Geomys.* The name *Geomydoecus scleritus*, given to a certain biting louse that usually infests pocket gophers heavily, reflects this exclusive relationship. Humus and decaying debris provide a food source for mites, springtails, and minute arthropods. These, in turn, are food for a variety of small predators—spiders, centipedes, and beetles—indigenous to these burrow systems.

Although pocket gophers do not normally eat insects, they must present a considerable hazard to their small coinhabitants because in its comings and goings, a pocket gopher's body practically fills its narrow underground runways. In order not to be crushed or buried in the soil that is often pushed in front of the gopher as it hurries along, delicately built insects such as the camel cricket must stay in different passageways or in small tunnels that they excavate for themselves. Captive blind camel crickets maintained in artificial burrows are quick to respond to any vibration by seeking some retreat. Those that cannot find cover scamper wildly about, then run down the burrows away from the disturbance until they locate a place of concealment.

Attempting to collect some of these commensal arthropods, I found that they fled from my digging activities and, in particular, the air that entered the exposed tunnels. Only if the tunnels were sealed from the outside would the various insect traps that I placed in the runways achieve results. Trapped insects had to be maintained in closed containers with high humidity; prolonged exposure to the outside environment proved fatal to most of them. Unable to survive outside the burrow, these specialized insects must disperse from burrow to burrow through temporary connections made by the gophers during the mating season or when the young tunnel off from the mother's system. This dispersal method must be an effective one, for every burrow system examined contained large numbers of these specialized arthropods.

There are also many free-living organisms commonly associated with the mounds of soil pushed up by pocket gophers. In the early 1960s, John Funderburg and I made an intensive study of the fauna associated with pocket gopher mounds. Frequent ground fires leave large areas almost bare of surface debris, and we found that animals seeking cover often used pocket gopher mounds as a refuge. Numerous invertebrates and at least twenty species of reptiles and amphibians were discov-

*Although males may occasionally come to the surface in search of a mate, pocket gophers spend almost all of their time below ground. As a consequence, they are seldom the victims of predators.*

ered living in the mounds. One-third of these were fossorial species that seem to be regular inhabitants of the mounds, and some, such as the sand skink and the mole skink, were seldom encountered anywhere else. The moist earth in the mounds creates a microhabitat that appears to be an important factor in the maintenance of certain amphibian populations during prolonged periods of drought, and several species of reptiles regularly use the mounds as a site for depositing their thin-shelled, leathery eggs. I have not conducted any follow-up studies to test the importance of this type of cover for small terrestrial animals, but from my observations I believe that several species would have difficulty living in scrub and sandhill habitats if it were not for these mounds. Most would probably exist at lower population densities.

Although there have been no studies in the Southeast, the impact of the gopher's digging has been documented in other regions. A thirty-year study of the northern pocket gopher, *Thomomys talpoides*, in Utah revealed that noncapillary porosity, organic matter, total nitrogen, and total phosphorus of the soil were considerably higher in areas where the rodent was present. This strongly suggests that *Geomys* may have an important role in the soil composition of natural upland habitats of the Southeast.

The current center of abundance of the southeastern pocket gopher is in north-central Florida, where numerous sand ridges provide great expanses of suitable habitat. Densities decrease outward from this area, with many outlying relict and semirelict populations in Florida, southern Georgia, and Alabama. The exact pattern of dispersal and later isolation are difficult to explain. Today the species is absent from many areas where apparently suitable habitat exists. Rivers, which could theoretically provide barriers to dispersal, might explain the absence of pocket gophers from some localities but seem to have little effect in preventing colonization of other areas.

There is considerable documentation, in historical times, of the decreasing range of the southeastern pocket gopher. Early lumbering removed most of the larger stands of longleaf pine, and in some of these areas thickets of turkey oak now predominate. More recent forestry practices use monocultures of faster-growing pines. In areas where there has not been extensive site preparation, pocket gophers are able to persist until the rows of young pines reach an age where they form a closed canopy. Then the herbaceous layer disappears and so do the pocket gophers. Because of the vast acreage of these tree farms, there is little opportunity for the animals to dis-

*Pocket gophers are highly tolerant of the raised levels of carbon dioxide in their sealed burrow systems, and their low rate of metabolism helps to limit both oxygen consumption and respiratory water loss.*

perse to newly cleared areas. The older residents of large sections of Georgia and Alabama remember "sandy-mounders" in places where they no longer occur. Forest fire-prevention policies have undoubtedly had a major impact on many fire-dependent savanna ecosystems. Annual plowing also eliminates pocket gophers from extensive agricultural areas. Farmers often kill animals that find refuge in bordering areas because these rodents do not restrict their diet to the rhizomes of grasses when something else is available. Young citrus groves provide suitable habitat, but many grove managers believe that gophers eat the trees' roots and usually try to trap them out.

Deprived of their ancestral habitat, southeastern pocket gophers are either extirpated or forced into artificially maintained habitats where they often become pests. In its native environment this beautifully adapted and highly specialized survivor of a Pleistocene ecosystem is an important contributor to its community, deserving of more than remnant stands of savanna and scrub. □

# Artful Diners

*For some caterpillars, table manners are a matter of life and death*

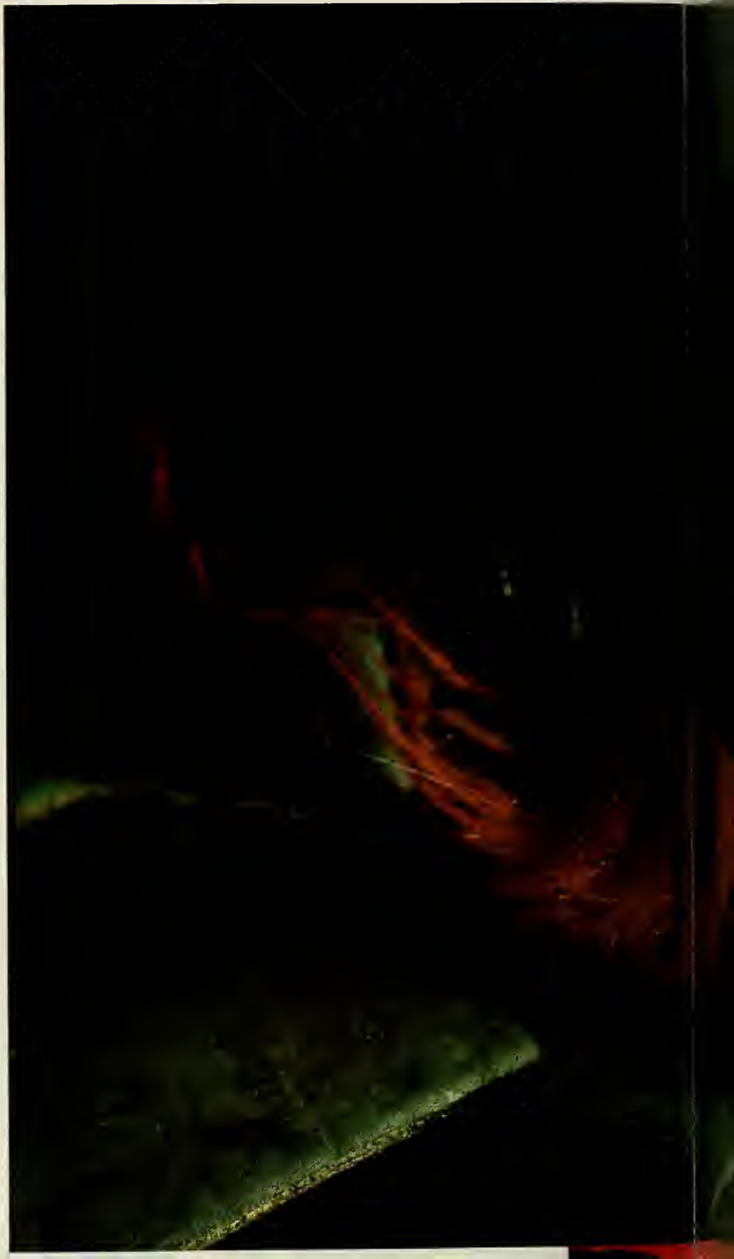
by **Bernd Heinrich**

After the trees regain their foliage in the spring, the larvae of innumerable species of moths and butterflies begin to feed on the leaves. In turn, the forests are invaded by hordes of birds that feed the larvae to their rapidly growing young. Thus, the danger of predation is high for many caterpillars. Nevertheless, their primary task is to feed and assimilate food that may be the sole supply of energy for the activity and reproduction of their adult phases.

Vertebrate herbivores also have to cope with predation. Squirrels, rabbits, and deer spend a large part of their foraging time scanning for predators and must often compromise feeding efficiency in order to be prepared to flee. Caterpillars, because they move so slowly, can do relatively little to escape birds that detect them. Their main defenses are to remain undetected or taste so bad that birds won't bother them. And bad taste must be advertised if it is to do its work in time, so noxious caterpillars are usually brightly colored and conspicuous.

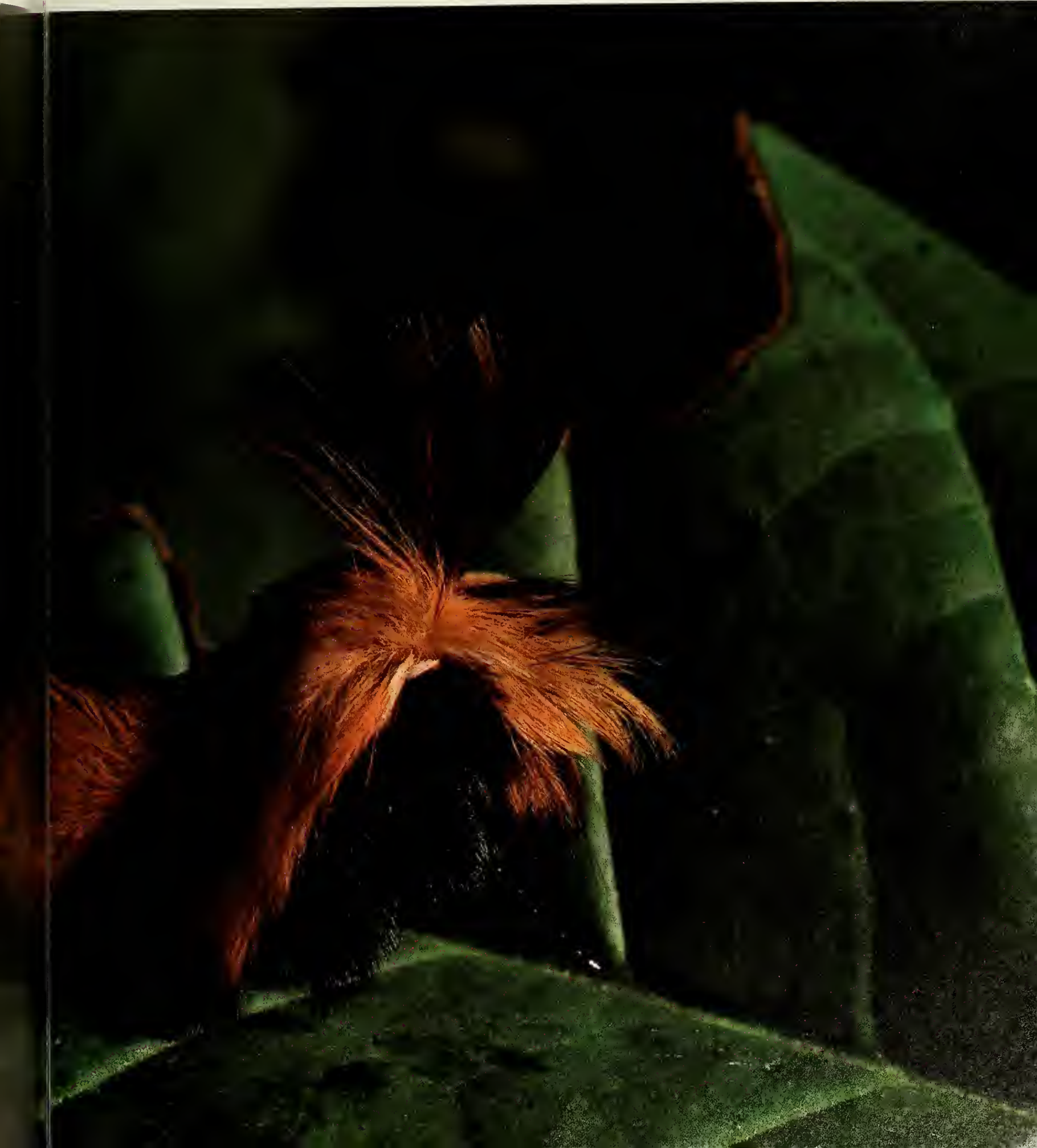
The evolved strategies of using poisons and irritating hairs and spines, as well as intimidating displays, are highly effective in repelling birds and other potential predators. But none of these strategies is effective against all predators at all times, particularly if a predator is hungry enough. The ideal strategy is to remain totally undetected. Some caterpillars approach this ideal, and the variety and sophistication of the strategies used by the hundreds of thousands of lepidopteran species to remain undetected bring to mind the words of the distinguished nineteenth-century naturalist Louis Agassiz: "The possibilities of existence run so deeply into the extravagant that there is scarcely any conception too extraordinary for Nature to realize."

The extravagances of caterpillars, and their effectiveness, are well documented in a vast body of literature that has been produced over the past century on the subject. But one problem has not yet received attention.



*Not a dog at all, but a moth larva (family Megalopygidae), this South American caterpillar is not pleasant to pet or to eat. Its hairs come off and lodge in the throats of predators, and stinging spines under the hairs add to its defenses. Thus armed and conspicuous, this caterpillar has no need to hide leaf damage, as its messily chewed perch attests.*

Kjell B. Sandved



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*Far left: This stick caterpillar (family Geometridae) feeds at night and remains motionless all day, at some remove from the leaf damage it has caused. It eases the strain of maintaining immobility by spinning a silk thread to tie its head to a twig. On the other hand, the saddleback caterpillar (family Eucleidae), left, advertises its stinging hairs with bright colors.*

Hugh B. Cott, who brought the subject of caterpillar defenses against predators up to date thirty years ago in a fascinating book, inadvertently suggests the problem when he describes a sphinx larva so effectively camouflaged that it "may as easily be discovered with the hand as with the eye. . . . The only clue as to its whereabouts is partially eaten leaves."

The problem, which neither Cott nor anyone since has investigated, is leaf damage. Do birds key in on leaf damage in searching for caterpillars? If so, then to remain totally undetected may present a problem to a caterpillar that uses its food, the leaves, as a source of cover. A caterpillar that consumes the cover over its head not only exposes itself but also leaves an indelible record of where it has been. It would seem that the caterpillars must do something to avoid this problem, and indeed, while studying the foraging behavior of caterpillars near Lake Itasca in northern Minnesota I found that a variety of caterpillar foraging strategies seem to have evolved as a compromise between feeding efficiently and avoiding predators.

Leaves come in an incredible array of shapes and sizes, varying from the long, needle-shaped leaves of pine to the broad ovals of tobacco. Sophisticated handling techniques are required to harvest these efficiently. Bees learn to handle different kinds of flowers to get the pollen and nectar, but for the most part each species of caterpillar feeds on one species of plant, and the way in which a caterpillar handles the leaves is inborn and automatic, having been fine-tuned through eons of natural selection.

In some cases the feeding behavior seems to have been shaped primarily to enhance feeding efficiency, rather than predator avoidance. The pine sphinx caterpillar, for example, is long and green striped, mimicking a group of pine needles. The caterpillar could potentially feed in the simplest way by biting into the nearest leaf tissue available (thus chopping needles off). It does not do so, however, unless it is confined in the crowded quarters of a jar or other container. When on a free branch, a larva always feeds on needles one at a time by "walking" up to the tip of a needle with its prolegs (while its clasper remains anchored near the base). The leaf bends, and the caterpillar begins to feed only when it reaches the tip. It then proceeds to eat the needle down to the base. After finishing, it "walks" up another needle to repeat the process. As a result of this behavior, no food drops to the ground to be wasted.

The consequences of wasting food are potentially critical for larvae that have large appetites and feed on small herbs that are scarce or widely distributed relative to the caterpillar's locomotor abilities. In the Mojave Desert, for example, the caterpillars of the tobacco sphinx feed on jimson weed. The widely scattered food plants are a scarce resource and are sometimes denuded by these caterpillars. In the laboratory ten years ago I observed that these caterpillars eat entire tobacco leaves by remaining under a leaf near the base, feeding forward from the petiole, and bending the leaf as feeding proceeds gradually to the tip.

Leaf bending not only results in economical harvesting but also shields the caterpillar from the sun and predators. The caterpillars routinely bite into the midrib and petiole near the base, thus bending the leaf toward them more easily, but they do not chew through the leaf near their perch, which would waste considerable amounts of food.

Not all feeding behaviors evolved for efficiency, however. Anne J. Alexander reported nearly twenty years ago that the larvae of certain heliconiid butterflies in Trinidad that feed on the leaves of passion flower plants (Passifloraceae) weave silk between the stalk of the leaf and the stem to which it is attached. These silk attachments guard against the leaf being detached while the caterpillar is on it. (Possibly the plant attempts to protect itself by shedding leaves that hold a caterpillar.)

Some heliconiid larvae crawl to the tip of a leaf, turn around, and then chew furrows into the leaf to the midrib. They then eat the portion of the leaf they have marked off. Alexander speculates that the furrows serve as territorial markers, moats of a sort, that may aid a caterpillar in defending its feeding ground against other larvae or predators. An alternative explanation is that the furrows are barriers against a chemical defense mounted by the plant against the caterpillar.

One South American caterpillar (genus *Anaea*) carves up the leaf of its food plant to leave uneaten a number of rough models of itself dangling near the midrib on which it perches. Presumably, birds pecking at the models are discouraged from finding the real caterpillar.

We know from many examples that the way caterpillars manipulate and feed on leaves is a highly complex behavior that has evolved under a variety of selective pressures. But we are not

Bernd Heinrich

*A dagger moth larva (*Acronita leporina*), thought to mimic the foam of spittlebugs or bird droppings, feeds while perched on top of leaves. To avoid leaving noticeable leaf damage that would attract birds, it "cleans its plate." After finishing a meal, it backs down the stem and snips off the remnant of leaf. Neatly severed stalks of previous meals are visible in the background of this sequence.*

certain that birds hunt for caterpillars the way most humans do—by looking for leaf damage. We can, however, examine the potential for such behavior. In addition, whatever cues they may use in locating caterpillars, the birds' searching strategies should have, over the millions of years, resulted in the caterpillars evolving counterstrategies. Thus, the behaviors of the caterpillars may reflect the hunting strategies of the birds.

The ability to recognize damaged leaves rests, first of all, on the ability to discriminate between different geometrical shapes. This ability is well documented not only in birds and other vertebrate animals but also in insects. Karl von Frisch long ago showed that honeybees learn to associate reward with specific geometrical designs. Other experimenters have shown that common pigeons, which normally have no need to differentiate leaf shapes, are able to discriminate between elm, maple, and sassafrass leaves, provided they are motivated by food rewards. (It is important to note that the pigeons are discriminating between classes of objects, for none of the leaves of any one species are identical.)

Russ Greenberg of the University of California at Berkeley has shown that in Panama the blue dacnis flies directly to leaves with feeding damage to glean insects, and the scarlet-rumped cacique specializes on insects hidden in leaf rolls. Also, in a study of the foraging behavior of the northern oriole in Colorado during an outbreak of pyralid moth caterpillars on cottonwood, Bruce Edinger of the University of Minnesota found that the birds keyed in on rolled leaves, unrolling them to extricate caterpillars that were totally hidden from view.

Rolling a leaf up and eating the roll from the inside is but one of many strategies evolved by caterpillars to escape predation. Like most such strategies, however, it is only effective until "found out" by the predator, and it is only found out, thus becoming disadvantageous, when it is common. This principle was demonstrated in 1952 by L. De Ruiter of Oxford University in his experiments on the camouflage of caterpillars that mimic sticks. De Ruiter found that chaffinches and jays do not normally peck at sticks, but if a bird accidentally finds a stick caterpillar, then it pecks at sticks that resemble these caterpillars. The birds continue this behavior only if they are rewarded occasionally. If the stick caterpillars become rare, the birds gradually desist from pecking sticks and stick caterpillars. Thus, when they are rare, camouflaged caterpillars enjoy relative immunity from predation, but when they reach epidemic proportions, they are disproportionately preyed upon and their populations are generally stabilized.

The same principles appear to apply to all predators, including humans. As a simple test I led my field ecology class at the Lake Itasca Biological Station to a balsam poplar sapling and instructed them to search for the four camouflaged caterpillars I knew to be on it. In previous tests they had all discovered different species of brightly colored noxious caterpillars within seconds. Search time was only limited by the time needed to scan the foliage.

This time, however, the sapling contained four stick caterpillars. The "predators" did not know what to expect, and they were instructed not to disclose to each other what they might discover so that they would search independently and without expectation. It required fifteen minutes before one of the six persons found one of the three 1.3-inch-long larvae. Thirty-six minutes elapsed before anyone found the other species of stick caterpillar measuring 1.6 inches in length. Two people with normal eyesight had not found the latter caterpillar after one hour, when I terminated the experiment because of student unrest.

Although the caterpillar leaf damage was evident at a glance, the larvae, which remain motionless throughout the daylight hours, were not resting near the leaf damage left from their nocturnal feeding. The leaf damage in this case was a reliable cue only insofar as it directed search to the appropriate tree. Like the hidden sphinx larvae de-

scribed by Cott, the caterpillars would have been discovered by the naïve human predators much sooner had they searched by hand rather than by eye. One person who did not find the large caterpillar nevertheless noticed a small nymph of a pentatomid bug walking within two millimeters of the caterpillar. Like De Ruiter's chaffinches and jays, the students, after seeing one caterpillar, were able to locate all of them within four minutes, even though they had been placed on another sapling. The experiment was repeated with other camouflaged caterpillars, and the results were similar.

The tendency of the untrained human predators was first of all to scan for chewed foliage. I would be surprised if birds, to whom finding caterpillars is a matter of life and death, rather than fun or college credits, did not also make use of this and other cues. A whole tree can be scanned for leaf damage in seconds, thus localizing subsequent detailed search.

The obvious strategy of the stick caterpillars, which I found to be shared by many other caterpillars prized by birds, was to feed only at night, when no birds were hunting for them, and to hide at some distance from the feeding area. A brown larva of the Abbot's sphinx moth, for example, often hid all day, pressed motionless against a grapevine, its food plant, six or more feet away from the large leaves that it could not possibly consume in one meal. This strategy is costly in terms of feeding efficiency because the early summer nights in the north are much shorter and cooler than the days. By feeding only at night, the caterpillars more than halve the time available for feeding; also, cool caterpillars feed much more slowly than warm ones.

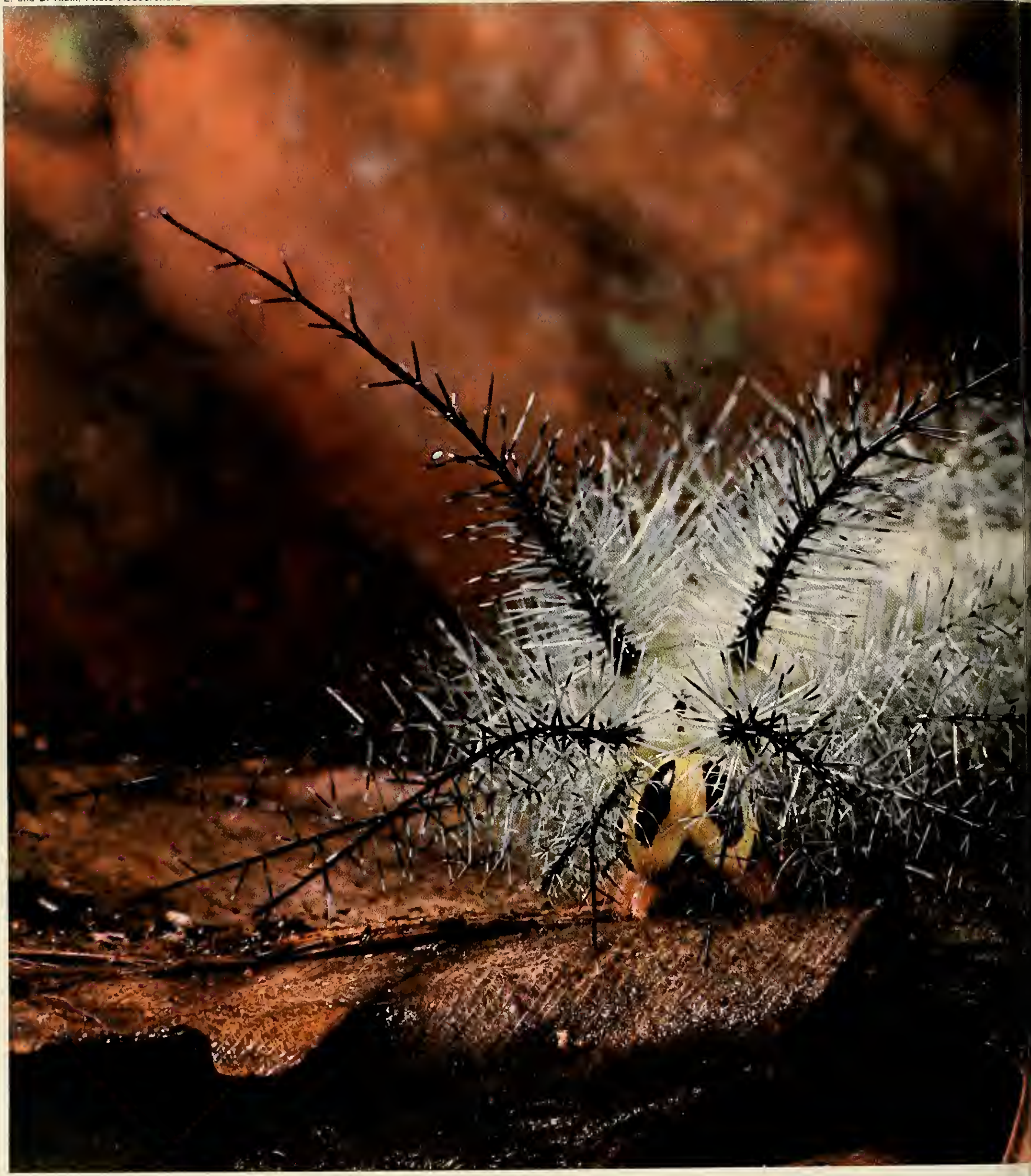
Some edible caterpillars eat both day and night, remaining permanently at the leaf without moving as much as a half inch from the feeding position until a leaf is finished. These caterpillars waste little time and motion and grow quickly through the dangerous larval period. But their camouflage must be excellent, and they must have a strategy to deal with the problem presented earlier: they must minimize the appearance of leaf damage. They do this in various ways.

The larvae of the hummingbird clearwing sphinx moth chew first one side and then the other of the leaves of viburnum, their food plant, gradually paring a leaf down in size, rather than chewing holes into it. While feeding, they remain partially covered by the leaf. The Cerisy's sphinx larva feeds at each poplar leaf until it is completely consumed before moving to the next leaf. A number of notodontid larvae combine mimicry of the leaf or the leaf petiole with a strategy of minimization of apparent leaf damage by resembling the leaf edge that they have just eaten. They feed forward on the leaf, "fitting in" the leaf they have consumed. To do this they attach themselves to the leaf edge rather than to the midrib or petiole. They mimic the leaf in its finest details, including blemishes, and in one species (*Nerice bidentata*) that feeds on elm, the jagged, toothed edge of the leaf.

In contrast to the above "clean" feeders, all of the noxious (spiny, poisonous) caterpillars are "messy" eaters. They feed while perched on the top of the leaf, often plainly visible, and leave conspicuous holes in the leaves, which can be seen from afar. For example, while feeding on willow, the spiny mourning cloak butterfly larvae generally consume the leaves to the midrib, starting from the base of the leaf and moving toward the tip. The tip of the leaf is usually left uneaten before the caterpillar starts on another nearby leaf. When many of these communal caterpillars are crowded together, they move around and eventually consume most of the leaves, leaving only the petioles and midribs. But when individual caterpillars are put on plants, they always leave messy, tattered leaves; no single leaf is fully consumed. Other unpalatable caterpillars, such as the poisonous monarch larvae, also only eat a portion of each leaf, leaving the rest on the plant. The hairy, unpalatable tent caterpillars leave conspicuous tatters on the huge, unfinished basswood leaves. But leaf size does not appear to be important: they also do not finish smaller leaves such as poplar and cherry.

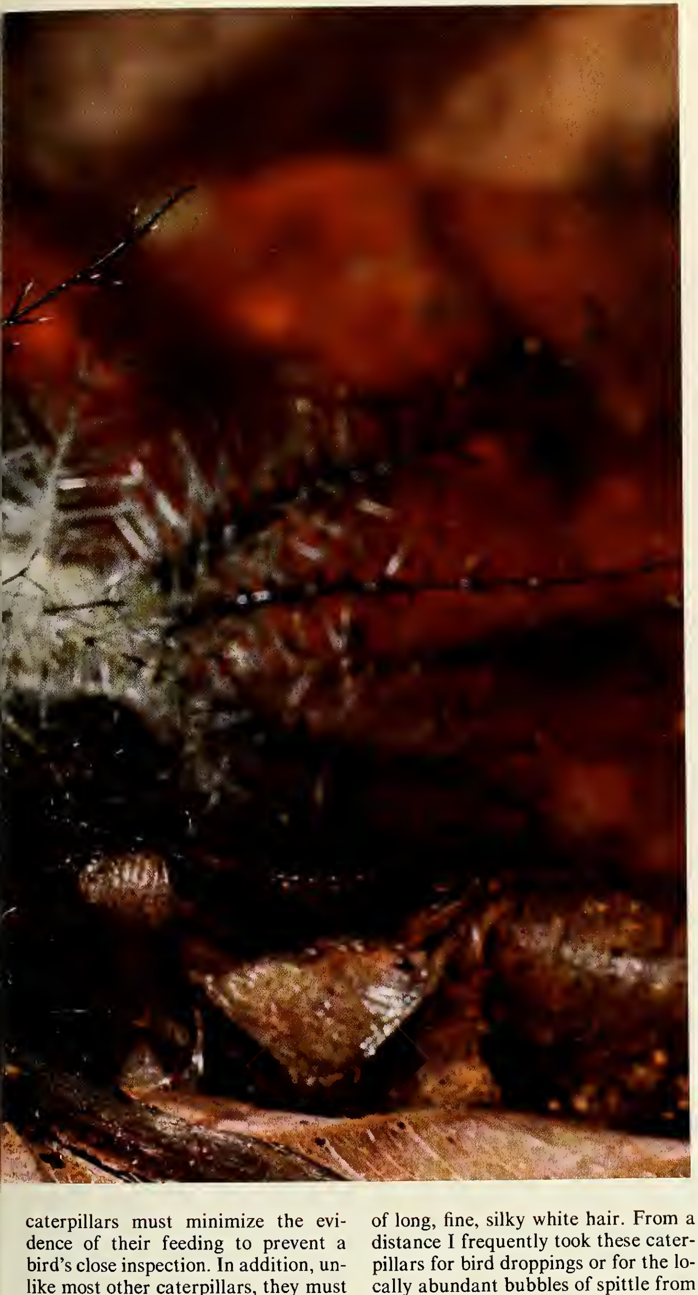
Messy feeding can, however, be raised to a fine art to confuse predators. The American copper underwing larvae also feed on basswood leaves, but unlike the tent caterpillars, these green larvae are highly desirable to birds. These caterpillars always remain underneath the basswood leaves, and they are particularly fond of hiding *between* two partially overlapping leaves. One large basswood leaf can supply most if not all the food for the entire larval growth of one of these

L. and D. Klein, Photo Researchers



small caterpillars. A larva could thus, because it has to feed, be condemned to advertise its presence for its entire life by the holes it leaves. However, after chewing a hole in a leaf from their hiding place beneath the leaf, these caterpillars immediately shift position, moving three feet or more to chew another hole in a distant leaf. As a consequence, a branch with one of these caterpillars soon has numerous leaves marked by conspicuous small holes, but the majority of these leaves have no caterpillar near them.

In contrast to hiding and blending in with the background, a variety of caterpillars all over the world have evolved to be white and visible. They rest and feed conspicuously from the top surface of leaves. It is thought that they mimic bird droppings, groups of woolly aphids, or possibly the spittle from spittlebugs. All of these models are inedible to birds, and the caterpillars' defense lies in being falsely identified. It is to their advantage to be seen from afar, since close examination would reveal any imperfections of their mimicry. If birds use leaf damage to localize their search, then these



*The emperor moth caterpillar (family Saturnidae), with its elaborate spines, has no need of camouflage.*

caterpillars must minimize the evidence of their feeding to prevent a bird's close inspection. In addition, unlike most other caterpillars, they must perch directly on the leaf surface, rather than on the petiole or underneath on the midrib. This should have consequences for their feeding behavior.

At Lake Itasca I observed larvae of two species of dagger moths with coats of long, fine, silky white hair. From a distance I frequently took these caterpillars for bird droppings or for the locally abundant bubbles of spittle from spittlebugs. (I was surprised to see them change their disguise overnight. Just before they start to wander on the ground to search for a pupation site, these caterpillars molt their skin, shedding their bright white coat for one with drab-colored hair that blends in with the background.)

As predicted, being on the leaf at all times while still growing, these caterpillars fed both day and night. But their feeding behavior showed other surprises. First, they fed alternately on each side of the leaf, gradually whittling it smaller and reducing their perch. Obviously, the remnant of the leaf could only be eaten from the petiole, but perching on the petiole would be inconsistent with their disguise: bird droppings are not attached to leaf petioles. One might predict that the simplest behavior of the caterpillars would be to crawl headfirst off a leaf when the perch becomes too small and climb onto a neighboring leaf, leaving behind a partially eaten leaf.

The actual behavior is by no means so simple. Because I never found partially eaten leaves near these caterpillars, I therefore made detailed observations to determine how they might dispose of them. Invariably, after the leaf perch became too small, the caterpillar backed down the petiole, stopped for a few seconds to chew through the petiole until the leaf remnant was clipped off, and only then, turned around to walk headfirst down the remainder of the petiole toward another, neighboring leaf. This highly complex behavior could not have evolved if it did not have functional significance, and it would have been perfected only under strong selective pressure, particularly since it wasted potential food.

The leaf-clipping behavior of edible caterpillars that mimic conspicuous inedible objects should be advantageous to other caterpillars as well. If birds cue in on leaf damage, they might also find camouflaged caterpillars that only feed at night and hide in the daytime. A caterpillar can only creep several feet on its food plant —distances that mean little to a foraging bird. A caterpillar well hidden on a twig might still be found by a bird searching near the leaf damage left by the caterpillar during its nocturnal feeding.

At Lake Itasca I found (after some practice) many catocola underwing moth caterpillars resting on basswood twigs that showed no overt leaf damage. Looking closer, I found that some of these apparently ungrazed limbs had nearly as many petiole stubs as whole leaves. It seemed unlikely that an underwing larva could eat a whole leaf in one night. The answer to this puzzle could be found by looking at the ground. Cleared ground under basswood trees was frequently littered with green leaves, and almost all of them were partially eaten in the feeding patterns of the underwing caterpillar. In addition, these fresh leaves on the ground had short petioles, rather than the typically long petioles of whole leaves. Leaves do not spontaneously fall off by breaking at their strongest area—the petiole. (The few whole leaves on the ground had the full length of the petiole attached to them.) These observations raised the interesting question, Could these caterpillars also be clipping off the leaves after feeding on them? I started to watch the underwing caterpillars feeding behavior directly and observed that, as in the dagger moth larvae, after a caterpillar finished a bout of feeding, it backed down the petiole and then chewed through it, causing the leaf to drop off. The caterpillar then turned around, crawled along the branch, and resumed its hiding posture on the branch, four to eight inches from where it had fed.

After making these surprising observations, I looked more closely at other caterpillars and observed the same behavior in another underwing caterpillar feeding on poplar, in the waved sphinx feeding on ash, and in big poplar sphinxes feeding on willow, with extremely short petioles, as well as on cottonwood, with extremely long ones. I also observed the behavior occasionally in the Abbot's grape sphinx and in a notodontid leaf-edge-mimicking larva on oak.

Furthermore, I found large numbers of partially eaten, chewed-off leaves under other forest trees—white birch, red oak, burr oak, and elm. Along one gravel road shaded by forest trees I found as many as forty-seven clipped leaves per square yard along the roadside, and for miles, the roadside was littered with freshly clipped leaves. I did not succeed in finding out which caterpillars had cut off these leaves, but once I started looking for partially eaten, clipped leaves, they suddenly became ubiquitous wherever there were trees over bare ground.

The practice of clipping off the remainder of the leaf after feeding appears to be a behavior common to many caterpillars and results in considerable wasted food. Interestingly, sphinx caterpillars that usually clipped off leaf remnants stopped this behavior on the last several leaves eaten before leaving the plant to pupate.

The leaf-clipping behavior is by no

*Scent papillae extended to emit a noxious chemical, this West African caterpillar (family Papilionidae) is using its second line of defense against predators, which it calls into play when its camouflage fails.*

means a haphazard accidental process. For example, Abbot's sphinx larvae chew through the petiole at a relatively specific point two to five millimeters from the leaf blade; nearly the whole long petiole is left on the vine. Since the vine and the petiole are of similar thickness and appearance, the caterpillar may thus avoid cutting through the entire vine (thereby destroying its entire food supply) by mistake. Caterpillars that are hairy, spiny, or poisonous, such as the tent caterpillars and the larvae of the monarch and mourning cloak butterflies, never chew through the petiole after finishing a leaf. Those caterpillars that eat the entire leaf, such as the larvae of the polyphemus, puss, and Cerisy's sphinx moths, do so occasionally.

In addition to leaf clipping, various other feeding behaviors of caterpillars may well have evolved under the selective pressure exerted by foraging birds. If this hypothesis is true, it has something to say not only about the caterpillars but also about the birds, whose foraging behavior may be more complex and sophisticated than previously thought. ☐

Kjell B. Sandved

# WHAT DO YOU THINK IT IS?

Need some help? Then consider the following:

The car you're looking at has a CIS fuel-injected engine that can take you from 0 to 50 in 8.5 seconds.

And power-assisted disc drum brakes that can take you from 50 to 0 in less than three.

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And front-wheel drive to give you responsive handling even in bad weather.

In back, there's a trunk so large it can hold six suitcases.

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And inside, there's room enough for a family of four.

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Well, maybe it would help to know that for all its impressive performance on the road, this car still turns in a pretty spectacular performance at the gas pump.

It gets an EPA estimated $\boxed{25}$ mpg, 40 estimated highway. (Use "estimated mpg" for comparisons. Your mileage may vary with weather, speed and trip length.

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This car doesn't look like what it is, and most people have a hard time guessing.

So why don't we just tell you.

We call it the Jetta.

Of course, Autoweek had a different name for it.

They called it, "another winner from Volkswagen."

# THINK AGAIN.

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# When Hail Breaks Loose

*A phenomenon of spring and summer, hailstorms are a menace to agriculture around the globe*

**by John Hallett**

Hailstorms cause about $700 million damage a year to crops in the United States. This is more than one percent of the total United States agricultural production. Hail is primarily a phenomenon of temperate climates. The hail season in the United States is spring and summer, April through October, and the area most frequently affected is where Colorado, Nebraska, and Wyoming meet, a region known as hail alley. But hail falls frequently in the plains of Kansas, Oklahoma, and Texas, along the Pacific coast from northern California to Washington, and occasionally in every state of the union.

Hailstones vary greatly in size and shape. They can be as small as a pea or as large as a grapefruit. They can be conical, round, or oblate, dimpled or knobbed with protrusions. The largest stones weigh from one to two pounds and fall at a speed of some 100 miles per hour. People have been reported killed by hailstones in India and a 1977 plane crash in Georgia was attributed to hail. But the greatest damage from hail is to high-value crops such as fruit and vegetables and is caused by small stones that can blanket the ground and occasionally accumulate to a depth of several inches.

How is hail formed? Hail is associated with thunderstorms, and while almost all thunderstorms probably produce hailstones, only some of these storms produce hail that survives to reach the ground. The size and severity of the storm, the water content of the storm cloud, the temperature, and the strength of the vertical air currents are some of the factors that determine the kind of hailstones that will form. Large-scale, severe storms with a high moisture content and strong updrafts produce hailstones of sufficient size to fall to earth almost intact. Less vigorous storms produce only small stones, which often melt as they fall.

Clouds that produce thunder and lightning—like all clouds that meteorologists label cumulus—begin as moist air near the earth's surface. When heated by the sun, the air becomes buoyant and rises. With increasing altitude, the pressure decreases, allowing the air to expand and cool. As the moisture condenses into liquid, drops form and heat is released. Thereafter, as the cloud continues to ascend, it cools somewhat more slowly and remains warmer than its surroundings, which become progressively colder at higher levels. Upward growth continues as long as the air remains buoyant. For thunderstorms, this process stops only when the cloud reaches the tropopause, a region of the earth's atmosphere about ten miles above the ground where the temperature begins to increase, rather than decrease, with additional altitude.

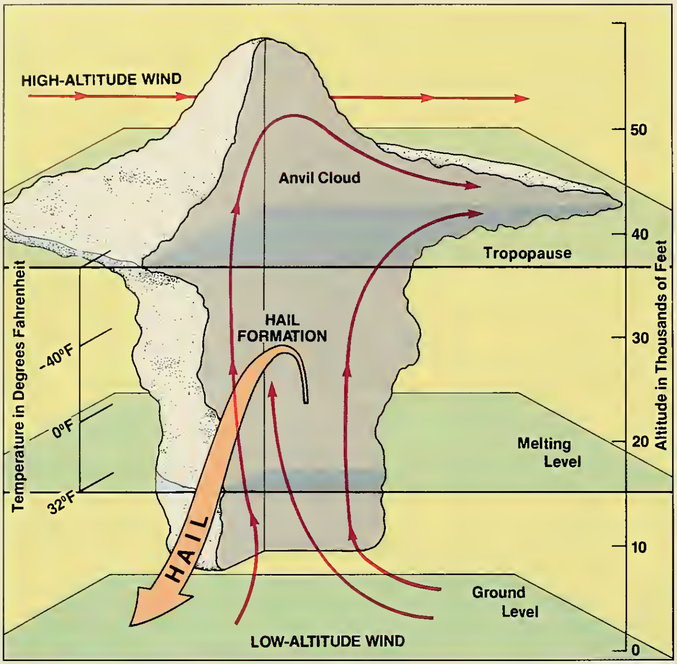
As a thunderstorm grows on a warm, sunny afternoon, the top of the puffy cumulus cloud can be seen first to grow upward and then spread out sideways when it reaches the warmer air of the tropopause. This gives the thunderstorm cloud its characteristic anvil shape. In less vigorous storms, the cloudy air rises at some 20 to 30 mph; in more severe storms the ascent can be as rapid as 100 mph. As already mentioned, this is also the speed at which the biggest hailstones fall.

At temperatures of as much as 60° F below the usual freezing point of water, clouds often consist of drops that have "supercooled," that is, have

*Hailstones come in a variety of sizes and shapes and can fall at velocities of up to 100 mph. They have been known to smash windows, dent car roofs, and kill antelope.*

Runk / Schoenberger from Grant Heilman

# Hailstone Formation



*Schematic section through a typical anvil-shaped storm cloud shows altitude and temperature at which hailstones form.*

remained liquid. Most liquids supercool in this way when divided into minute droplets. For these supercooled liquid drops to start freezing, tiny impurity particles that serve as a nucleus must be present. A bucket of water usually has many such particles, which cause the water to begin freezing at only one or two degrees below the freezing point. In a thunderstorm cloud, only about one in a million drops contains such particles, most of which are dust or tiny bits of mineral that originated in clay soils and were carried aloft by the rising air. Although the cloud drops themselves are quite small —their diameter is about the same as that of a human hair—they are still some hundred times bigger than the particles that cause them to freeze. The atoms in these particles are arranged in a hexagonal pattern just like those in natural ice crystals. Although their spacing is a little different, from the point of view of the surrounding water molecules these particles mimic an actual ice crystal and cause freezing at temperatures of only 20° or so below the freezing point of water, which is 40° higher than pure water.

After a supercooled drop freezes, it grows in the form of a snow crystal. When it reaches a size of almost one-hundredth of an inch, it can fall fast enough to collide with still liquid neighboring cloud drops. The colliding drops freeze to each other on impact and form a light, air-filled aggregate that resembles fresh snow. These aggregates are soft hail particles that grow in a conical shape and can attain a size of about a half inch. They are oriented with their growth side facing downward as they fall, collecting more and more moisture drops on their broadening base.

When cloud drops are collected in this manner at a rate so fast that there is not sufficient time for each drop to freeze individually, hard hailstones form. As additional liquid drops collide with these growing, falling hailstones, they splash against the stones and some of the drop water spreads out to form a thin liquid layer that freezes from the inside out. This process takes place with faster-falling larger stones and also with stones—approximately the size of cherries to golf balls—that grow in clouds containing a large amount of water.

In the bigger storms, the hailstones sometimes grow to resemble a wet snowball. Not enough of the heat of freezing is carried away by the air to allow the collected water to freeze solid, and a mixture of ice and water results. Differences in the amount of water present in different parts of the storm cloud through which the stone falls result in either clear or opaque ice layers on the stone. Opaque ice is caused by small air bubbles that develop if the water drops freeze so quickly that the air dissolved in the water cannot be expelled. Clear ice results from drops that freeze more slowly. Alternating layers of clear and opaque ice are characteristic of large hailstones that are kept aloft by strong updrafts as they grow in air that contains varying amounts of liquid water. A large stone may have as many as ten or more of these alternating layers, which can be readily seen when the stone is sliced into thin sections.

The center of a large stone is sometimes a conical soft hailstone; on other occasions it can be a frozen raindrop. The smaller stones grow on one side only, in the shape of a cone, like soft hail. Oblate stones result from occasional flipping while falling to the ground. Knobby stones result from the preferential collection of cloud drops on irregularities that were initially formed at random. Individual knobs can grow as long as one inch.

Only a few soft hailstones or frozen raindrops grow to become large hailstones. The updraft in the thunderclouds carries the smallest stones up and out of the cloud top; others melt as they fall. Hail that develops into large stones grows continuously, often remaining suspended near one altitude, several miles above the ground, for as long as ten to twenty minutes before falling out. This can happen when the fall velocity of the largest hailstones is identical with the maximum updraft velocity in the cloud. In storms that occur from Colorado to Texas, well-organized updrafts occasionally reach sufficiently high speeds to keep the growing hailstones aloft until they achieve the size of a grapefruit. These stones will fall when their fall velocity becomes great enough to overcome the updraft or the updraft weakens.

Can hailstorms be suppressed? Attempts to modify them have been made throughout history. The Romans shot arrows toward the storm. In medieval Europe, church bells were rung—a practice that tended to increase the casualty rate because lightning often struck the unprotected belfrey, electrocuting the bell ringer. With advancing technology, the hail cannon, a device that fired a ring of smoke and gas instead of a solid missile, became popular. The sound of the discharge was supposed to break up the hailstones. It at least provided some psychological comfort. Cannons were later replaced by rockets, which exploded aloft with a resounding bang. None of these remedies had any obvious success.

In recent years, the concept arose that artificially increasing the number of ice particles in storm clouds might produce a relatively larger number of the less damaging very small hailstones, which would melt before reaching the ground. This possibility became a reality in 1946 when it was discovered that the dispersal of pellets of dry ice, at a temperature of –95° F, or of silver iodide smoke (whose particles act on an atomic scale like tiny ice crystals) causes ice crystals to form in a sufficiently cold cloud. But this seeding technique must be used very carefully since only a small increase in the concentration of hailstones might make matters worse.

In spite of many uncertainties, hail suppression experiments have been undertaken around the world with varied claims of success. Rockets now used in the Po Valley of northern Italy contain silver iodide and are fired so as to explode in the heart of approaching storm clouds. The hope is that this will cause the production of a large number of ice crystals that will spread out and form small, harmless hailstones. Local farmers support the operation and believe it is useful. A project in Switzerland in which silver iodide smoke was released from burners on the ground indicated that while the hail was not significantly changed, the rainfall was enhanced. Aircraft seeding of hailstorms with silver iodide has been carried out in Kenya and South Africa, with claims of some hail reduction. Russian experiments in 1961 in the Caucasus, for which a striking degree of success was claimed, fired artillery shells containing silver iodide into likely looking clouds, identified by a large radar echo.

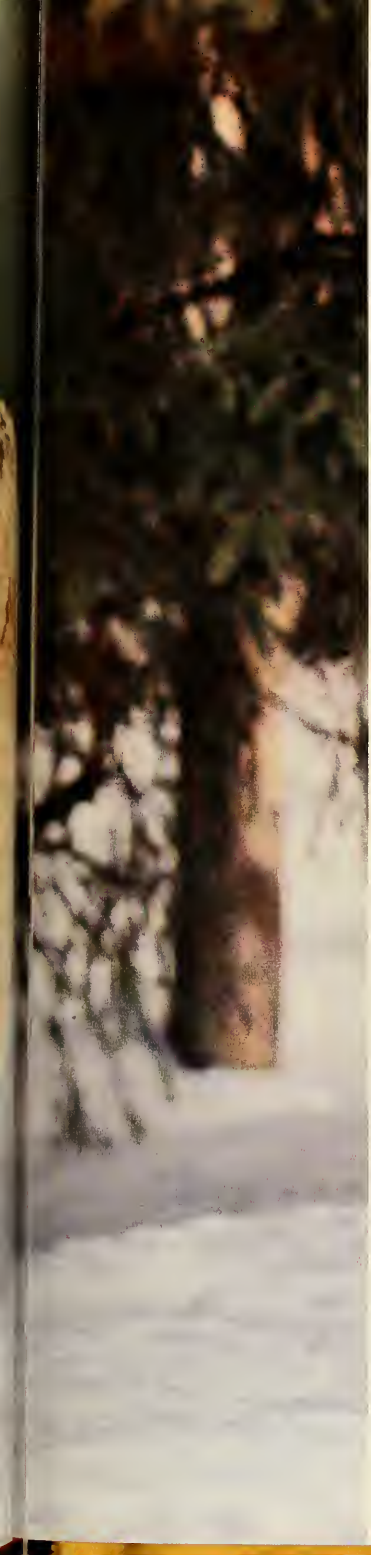
Assessing the results of these experiments is not easy. There is no doubt that the silver iodide that reaches the colder region of supercooled clouds produces ice crystals; the question is whether the crystals are distributed widely enough to have the desired effect of forming the centers of a sufficient number of small hailstones. Many scientists were and are skeptical of the statistical techniques used to claim success. Could a claimed reduction of hail have occurred through natural variability? Hail fall is notoriously changeable from place to place and time to time.

Recent experiments aimed at testing these claims of hailstone suppression were carried out in Colorado from 1972 to 1974. The experiments, designed to investigate the effect of seeding hail clouds with silver iodide released from aircraft, used an extensive array of instruments to measure the amount and size of hail falling at the ground. The results tended to be inconclusive, although very large effects, such as the 60 to 70 percent reduction in hail claimed in the Soviet Union, were ruled out.

There is still much to learn. Even if we were able to modify some hailstorms on a local scale, other storms are so large that the use of aircraft or rockets would present a formidable technological challenge, and the possibility always exists of inadvertently enhancing the hail fall on the edges of the very areas chosen for protection. Because the optimum conditions for the growth of agricultural crops and hailstorms remain the same—a warm and moist climate—raising crops in hail-prone regions will continue to be a risky undertaking for a long time to come. ☐

John Colwell from Grant Heilman

*This mangled cantaloupe is representative of the multimillion-dollar crop damage done annually by hailstorms.*



# Wolves in the USSR

*The state of the art of Russian wolf management*

**by Dmitri Ivanovich Bibikov**

For centuries, man has engaged in incessant and persistent struggle against the wolf, a highly organized, large predator preying on wild and domestic ungulates. This strife has resulted in wolf extermination in many Western European countries and in most of the United States. The existence of the species is endangered even in Europe's most protected mountain areas—the Pyrenees, the Apennines, the Balkans, and the Carpathians.

Diminished wolf range and numbers appear to be inevitable with increasing human transformation of the landscape, population growth, and urbanization. This process is natural and in some ways justified, since in developed areas the wolf's regular functions are taken over by man. Game management evidence from some European countries shows that high numbers of wild ungulates and their good physical condition have been achieved in the absence of the wolf. There is also no doubt that farmers, cattle breeders, and hunters would be opposed to paying a tribute to the wolf by reintroducing it into its original range.

Recently, ecologists have given strong evidence of the wolf's positive role in maintaining equilibrium in ecosystems little disturbed by man. This role consists of control of ungulate numbers and maintenance of population fitness. But the decrease of wild nature offers little chance of wolf preservation in most of its range.

*The central Russian forest wolf, which can weigh up to 175 pounds, is the largest subspecies found in the USSR. Its favored prey is moose (called elk in the Soviet Union).*

S. Marakov

In the USSR, the wolf is a common and widely distributed beast badly affecting cattle breeding and game management. Similar to the New World, in the USSR the geographical variability of the wolf has received little attention. In the Soviet Union, seven wolf subspecies have been distinguished, distinct as to size and coloration. Their ranges and morphological features call for further investigation.

The wolf is not an endangered species in the USSR. This is why control is still an urgent problem where the wolf is a human competitor, for example, in areas of extensive cattle breeding and management of ecologically important wild ungulates.

In the USSR, the current century has seen two peaks of wolf numbers, both of which followed years of war and economic difficulties when wolves were not controlled. At the end of the 1940s, the number of wolves in the country was roughly estimated at 200,000, and they were affecting cattle badly. Active control, with annual kills of 40,000 to 50,000 head, reduced the wolf population considerably by the early 1960s. The annual kill number was then fixed at 15,000.

However, the early 1970s saw a new rise in wolf numbers. In the Ukraine, in Byelorussia, and in central Russia, wolf populations increased twofold over a five-year span. The reasons were slackening control efforts, re-

Warren Garst: Tom Stack and Associates

*Ranging throughout much of temperate Europe and Asia, the red deer is essentially similar to the North American elk. Wolves take a toll of fawns and old and injured individuals.*

duced wolf density, and popularization of natural conservation. In recent years, hunting agencies and societies have contributed considerably to increased efforts at controlling wolves. Conducive to control were such measures as an increase in the premium for killed wolves: for an adult it is now up to 100 rubles and for a young, up to 50 rubles. Wolves are killed throughout the year by all means, including shooting from helicopters, vehicles, and aerosledges.

Undoubtedly, wolf numbers will again drop below the early 1970s level; that is, there will remain fewer than 50,000 wolves in the USSR. Their range in the European USSR is likely to be reduced to half of what it once was. But wolf populations in the mountains of the Caucasus, Central Asia, and Siberia are not likely to decrease in the near future. These are sparsely populated areas, difficult of access, and no effective hunting techniques are available.

Wolf populations are most vulnerable in open landscapes—tundra, steppe, and desert—where hunters use aircraft. Wolf-control data for open landscapes indicate that the tundra *Canis lupus albus* and desert *C.l. desertorum* subspecies are endangered. Preservation of genetic variety within any species being important, this can hardly be justified.

With a huge range and environmental diversity, wolf ecology in the USSR varies to a great extent geographically. First and foremost, this involves population densities and feeding. The wolf being a territorial animal, both in the Soviet Union and the United States, population density may exceed one individual per ten square miles only in such exceptional cases as in ungulate winter yards and in some reserves. For six years, sixty wolves inhabited the Kzyl-Agach reserve in Azerbaijan, an area of less than 400 square miles. The wolves maintained the population of wild boars on which they largely fed at a relatively stable level of 700 to 800 individuals. About 100 wolves dwell in the Caucasian reserve, which has an area of 1,000 square miles. Fifteen resident packs in the reserve remain in permanent home ranges of 25 to 60 square miles. Territoriality limits wolf numbers in these reserves. (These are biosphere reserves—no hunting or timber harvesting is allowed and only limited recreation is permitted.)

Wolves used to be abundant in the forest-steppe zone of central Russia, the Ukraine, Povolzhie, and western Siberia, but systematic human pressure has considerably reduced these populations. A density of ten to twenty individuals per 400 square miles has only been recorded in highly wooded, sparsely populated areas. In the tundra and desert, the wolf has always been scarce, the mean density not exceeding one to two individuals per 400 square miles. We have recorded wolf population densities of up to twenty individuals per 400 square miles in the range of the saiga antelope—an animal that has recovered greatly from near extinction—in the Aktyubinsk region of Kazakhstan.

The diet of the tundra wolf is wild and domestic caribou, and in the eastern part of the region, bighorn sheep as well. Taiga wolves feed mainly on elk. In Siberia and the Far East, the wolves' diet is supplemented by deer, roe deer, and wild boar. When ungulates are scarce, blue hare is an important component of the wolf diet. In the western forest-steppe region, the wolf takes roe deer (the Baltic republics, the Ukraine), wild boar (Byelorussia), and deer. In the desert zone, the bulk of the wolf diet includes saiga and goitred gazelle, and in the river valleys, deer and wild boar. In mountain-forest ecosystems, the wolf consumes deer, wild boar, mountain goat (in the Caucasus); mountain sheep, roe deer, deer, wild boar, and mountain goat (in the mountains of Kazakhstan and Central Asia). The role of domestic ungulates, specifically sheep and goats, increases in the wolf diet where pasture livestock farming is well developed and wild ungulate resources are small.

Seasonal variability in wolf feeding is marked by a reduction in the proportion of ungulates in the summer diet, a time when small animals are abundant. The intake of carrion also increases in summer. Feeding specialization in individual wolf families has also been recorded. For example, over a number of years the major diet component of a wolf family in the Caucasian reserve was deer; that of a neighboring family was mountain sheep and wild boar. Near the edge of this reserve, some wolf families specialized in killing domestic animals. Most frequently, those were nonterritorial groups. It appears that techniques of hunting certain prey types were passed on to offspring.

The wide dispersal of wild boar in central Russia in the 1960s and 1970s has so far not resulted in a wolf changeover to feeding on them. The wolves continue to consume their traditional diet—elk. In recent years, however, evidence has been recorded of some wolf families killing wild boar.

Studies of wolf relations with ungulate prey have been the focus of attention in the USSR. Naturally, a diversity of prey species and environmental conditions over vast areas has led to highly contradictory inferences. The wolf's role as a population quality improver is definitely not appreciated in areas where the predator under study lives on domestic animals. Many game-management specialists regard the wolf as harmful. A number of publications are available on red and axis deer population reduction by wolves, specifically where these animals have been introduced. Ungulates acclimated in game preserves invariably lose their capacity to resist wolves. The selective role of the wolf, well studied and necessary in wild nature, has been lost under such conditions.

Along with their American and Canadian colleagues, Soviet scientists have given conclusive evidence of the wolf's useful role for its prey populations in ecosystems slightly affected by man. In fact, studies in Crimean reserves have demonstrated a degeneration of red deer in an overdense population in the absence of wolves. Similarly, a sharp reduction of wolf numbers brought about a substantial increase in the number of sick caribous on the Taimyr. Similar evidence is provided by the Darwin reserve, where the elk population was healthy, its numbers increasing despite annual kills of about fifty animals by numerous wolves. Following the introduction of wolf control, the Darwin elk herd was reduced by bad skin diseases.

Observations in the Caucasian reserve revealed population growth in deer, wild boar, and mountain goat during a period of intensive wolf control, the number of the wolves being reduced to between twenty-five and thirty by 1960. The number of ungulates exceeded 30,000, and winter feeding yards were destroyed under the impact of too many animals. From 1965 to 1971, few wolves were killed, and their population increased. Ungulate populations subsequently began to decrease. From 1971 to 1975, the predator-prey ratio was stabilized at 1 to 300. This allowed an average take of 4,800 pounds of prey per wolf per year. Both pastures and the physical condition of the deer have improved. In the area under study, as in the United States, deer six years of age and older (59.2 percent) and fawns (25.1 percent) were preferentially killed by the wolves. Comparison of evidence indicates that wolves have a less deleterious effect on ungulate reproduction than human hunting, which eliminates the most productive animals.

The wolf's epizootic role is not yet clearly understood. Many authors emphasize that wolves eliminate sick members, which makes the prey population healthier. A considerable body of evidence is available, Soviet sources included, on the wolf's pathogenic role, particularly in regulating helminthoses. Also imperfectly understood is the role of the wolf in retaining the rabies virus. The wolf carries and transmits this infection in nature; however, the virus can exist in the absence of the wolf. Foxes and raccoon dogs are prime carriers in some Western European countries. It should be taken into account that in the presence of the wolf, fox numbers are not high.

Wolves hunting saigas exhibit a pronounced prey selectivity. During the rut, for instance, wolves are known to take weakened and exhausted males most frequently. Similarly, during fall saiga migrations we observed wolves keeping near small antelope groups that followed the multithousand major herds. In such small groups, the proportion of inferior and wounded individuals is high (up to 5 percent). Creating test situations through pursuit of small groups, the wolves overtake the

I. Bavykin

*Nuzzling up to their mother, two pups display the close familial bonds of wolves. Social status, so important in the hierarchy of a clan, begins to be formed at this age.*

inferior individuals lagging behind. Dead saigas, which are common on migration pathways and, specifically, at human hunting sites, are another source of easy food.

Wolves are not always so selective when preying on saigas. For instance, when wolves take pregnant females and newborn young it is a matter of chance as to which will fall prey. The death rates of pregnant females and young are negligible, however, because of the large concentrations of saigas. It appears that the concentration of many thousands of calving females in a territory of a single wolf family is an adaptation of the saiga to wolf predation. According to our observations the death rate of young saigas reaches 20 to 30 percent in the inferior groups that lag behind the main herds. Small stray groups of pregnant females are hardly a population elite, however, and their high loss of young to wolves may actually benefit animals in the major herds by reducing predator pressure on them.

No selectivity in wolves taking saigas appears to be operating at river crossings. The antelopes are aware of the water obstacle hazard and approach it with great caution, avoiding reeds and other cover that wolves use. If the predators manage to attack saigas during a crossing, losses are bound to be great: dozens of saigas of both sexes are commonly killed.

There occur situations when wolves kill quite healthy and efficient individuals. This happens under deep snow-cover conditions when frozen crust handicaps ungulate escape. The possibilities of useful selection are also limited in wild boar and Caspian seal populations, since wolves largely kill young individuals. Thus the problems of wolf–ungulate management are very complicated, no unambiguous solutions existing.

Changes in wolf ecology and behavior under human impact, in particular, years of hunting, have not yet been considered. These are of great interest, as a high degree of nervous activity in wolves has resulted, as well as a demonstration of their high capacity for adaptation to new conditions.

Although the wolf is now most abundant in sparsely populated territories, its present-day distribution is of a secondary nature, having been caused by human activities that ousted the animal from densely populated areas. As early as the beginning of the current century, the wolf's optimum range was in the forest-steppe zone where it preyed mostly on domestic animals—wild ungulates having been long exterminated. The wolf's range widened following human distributional patterns. The change in range can be best traced in the plain-taiga zone, a landscape unfavorable for the wolf because of its deep snow cover in winter. The expansion of the wolf range in this zone was fostered by the following factors: an increase in the road network due to logging (which facilitates the wolf's movement under deep snow conditions), new settlements, and better feeding conditions at the expense of wild and domestic animals. The wolf penetrated to the arid deserts of Turkmenia and Uzbekistan thanks to irrigation and formation of water reservoirs near artesian wells.

Along with a marked trend to avoid humans, the opposite behavioral pattern has also been observed in the wolf. Not infrequently, wolves have adapted to living near man to feed at dumps and livestock burial sites. A similar pattern has been revealed for coyotes in the United States.

Under conditions of human harassment, familial wolf groups tend to break up and total population numbers are reduced. The wolves acquire greater mobility; they migrate frequently and at longer distances. Our observations of wolf packs in the Smolensk region revealed that in winter wolves would often migrate over distances of 18 to 24 miles, leaving their territory completely during a single night. They would return after a few weeks, but commonly only for a short time. Extensive migrations have also been recorded in the Ryazan region.

In addition to large-scale migrations and a partial loss of territory conservatism in some wolves, a substantial change in the pattern of using killed prey has emerged in recent years. Where previously, a pack kept near the dead prey for a few days, wolves now only confine themselves to a single feeding, after which they move long distances. This new behavior precludes the use of bait to keep the wolves at the site for better hunting.

Generally, wolf behavior is most conservative. This is particularly true for their habit of howling. It would seem that an animal that changes its behavior flexibly to protect itself would find it natural to get rid of this habit, which attracts hunters and hence is fatal to survival. However, this does not happen. The communicative significance of howling must be so high that this behavior cannot be rearranged even at the hazard of species survival.

The situation in regions where the structure of the wolf population has been depleted through extensive control is quite peculiar. Unable to find a mate, lone wolves (both males and females) mate with dogs, which yields cross populations. This is a most unusual adaptation to extreme conditions created by man. Currently, such crosses have been recorded in more than ten regions in the USSR, and their numbers and ranges have been increasing. Wolf-dog crosses studied in the Voronezh region resembled wolves externally or were intermediate. The bulk had wolf fur coloration but black-and-white patches were found in many individuals. Crosses are closer to true wolves ecologically, but they are less robust, preferring to attack small livestock, fowl, and dogs. By the early 1970s nine populations of wolf-dog crosses were recorded in the Voronezh region. By 1976 only three of them remained following a recovery in wolf numbers from 22 to 26 to 230 to 250. The earlier reduction in wolf numbers followed the occupation of the woodlands by wild dogs, which badly affected all living things, deer included. With wolf population recovery, wild dog numbers were reduced. Thus the problem of wolf control is complicated enough.

The solution calls for profound studies, including the problems of the expansion of the ranges of crosses and wild dogs. In recent years wolf ecology studies in the USSR have intensified. Data obtained should form a basis of wolf control measures that will reflect a differential attitude to this animal in keeping with its actual role in the economy and wild nature. The regional projects of wolf control will reduce the wolf's range in the USSR. This reduction is necessary in many areas, but preservation of the diversity of ecological and geographical wolf forms should also be stressed. ☐

*In the central Russian twilight, a wolf pack gathers at a favored rest site on the border between dense forest and open fields. Potential prey can be easily spotted from such a vantage point.*

N Rukovsk

*Recent drought in the Midwest devastated the corn crop. In like manner, severe droughts in the Great Plains during the twelfth and thirteenth centuries are believed to have destroyed the agricultural base of the Indians of the region.*

All photographs by Jim Brandenburg

# Ancient Climes on the Great Plains

*Past variations in climate wrought dramatic changes in the life styles of prehistoric plains peoples. Future variations could have similarly far-reaching consequences.*

**by Reid A. Bryson**

The environmental factors that affect human occupation and use of the land must be taken into consideration if we are to understand history. Climate is one of these factors. It helped to shape the history of the American West and may play a comparable role in shaping the region's future. Two examples from American prehistory should suffice to make the point.

The Indians of the northern part of the Great Plains, a vast area that stretches roughly from the eastern slopes of the Rocky Mountains to beyond the Mississippi River, once lived in villages scattered across the region. They grew rain-fed corn and hunted deer and bison. Radiocarbon soil dating indicates that after about A.D. 1200, the villages were abandoned and became covered with wind-blown dust. Studies show that the twelfth century marked the beginning of a two-century-long period of frequent drought in the northern Great Plains. Variations in airstream patterns are presumed to have been the cause.

Similarly, the Pueblo Indians of the Mesa Verde, in what is now southwest Colorado, abandoned their homes about the year 1300 after having successfully maintained an agricultural society in the area for several centuries. Tree-ring studies indicate that a succession of severe droughts over several hundred years probably made farming impossible and caused the Pueblo Indians to migrate south and west.

Our western climate can be understood only in terms of special topographic features. The American West is primarily a high plateau, with mountain ranges that modify the flow of air across its surface. This combination of mountains and mid-latitude westerlies blowing almost at right angles to them dominates the climate of most of the North American continent, even far east of the Rockies.

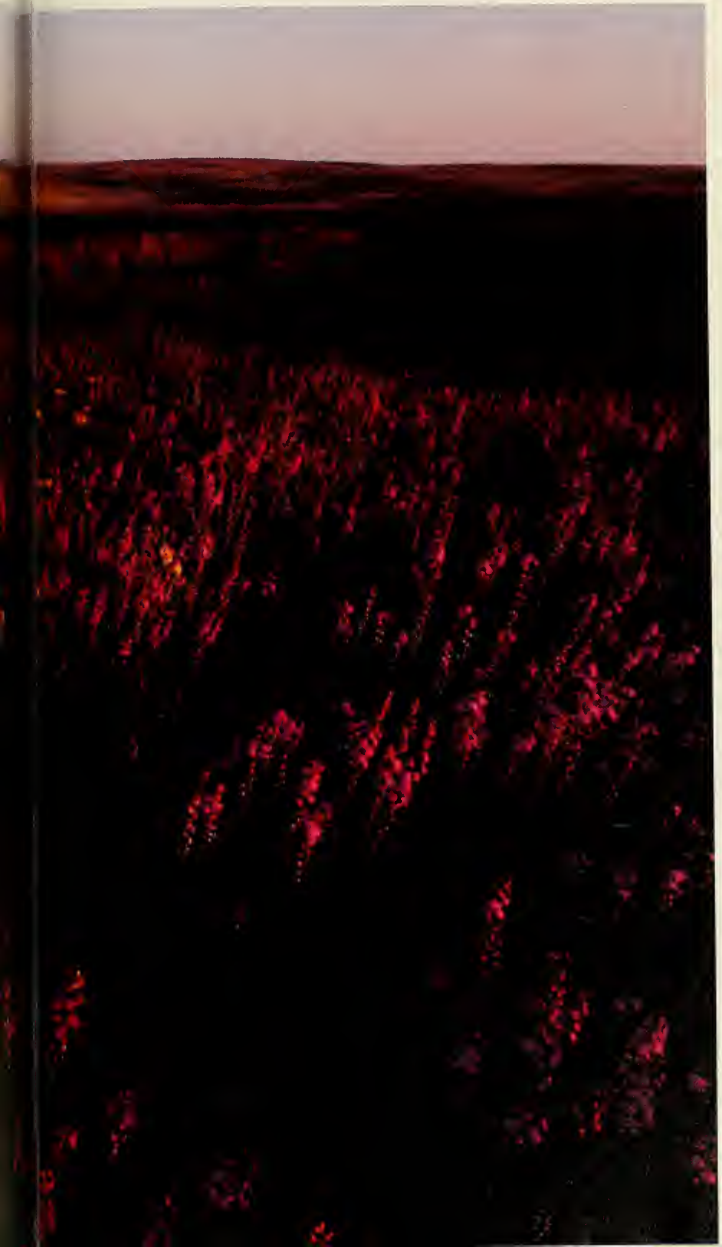
In essence, the western United States is too high for most of the moist low-level air coming from the West Coast to cross. The kinetic energy of the west winds is usually insufficient to enable the air to rise from near sea level along the Pacific coast to the crest of the Sierras and the Cascades. Much more air leaves the east side of the Cordilleras near the ground than arrives at the West Coast near the sea. (The Cordilleras is the North American mountain system that includes all the mountains between the Rockies on the east and the Pacific coast.) The excess comes from atmospheric levels near the height of the plateau—about 4,000 to 5,000 feet. Because of the location of the various western mountain ranges and the character of the air, there are three dominant routes by which this mid-level Pacific air moves eastward to the Great Plains. These may be thought of as the Southern Pacific, Union Pacific, and Canadian Pacific routes, for those railroads were laid out to take advantage of the least difficult passages through the mountain ranges.

The southern route for the eastward passage of Pacific air, roughly along the Mexican border, carries the greatest flow in winter when the westerlies are far south. This air passes over the

southwestern desert in California and Arizona and south of the Rockies, and flows across either the semiarid southern portion of the Great Plains, known as the Llano Estacado, which extends over most of the Texas Panhandle and part of New Mexico, or northward along the Front Range of the Rockies about as far as Denver. The air is seasonally hot and very dry as it descends down the slope of the mountains and into the Great Plains.

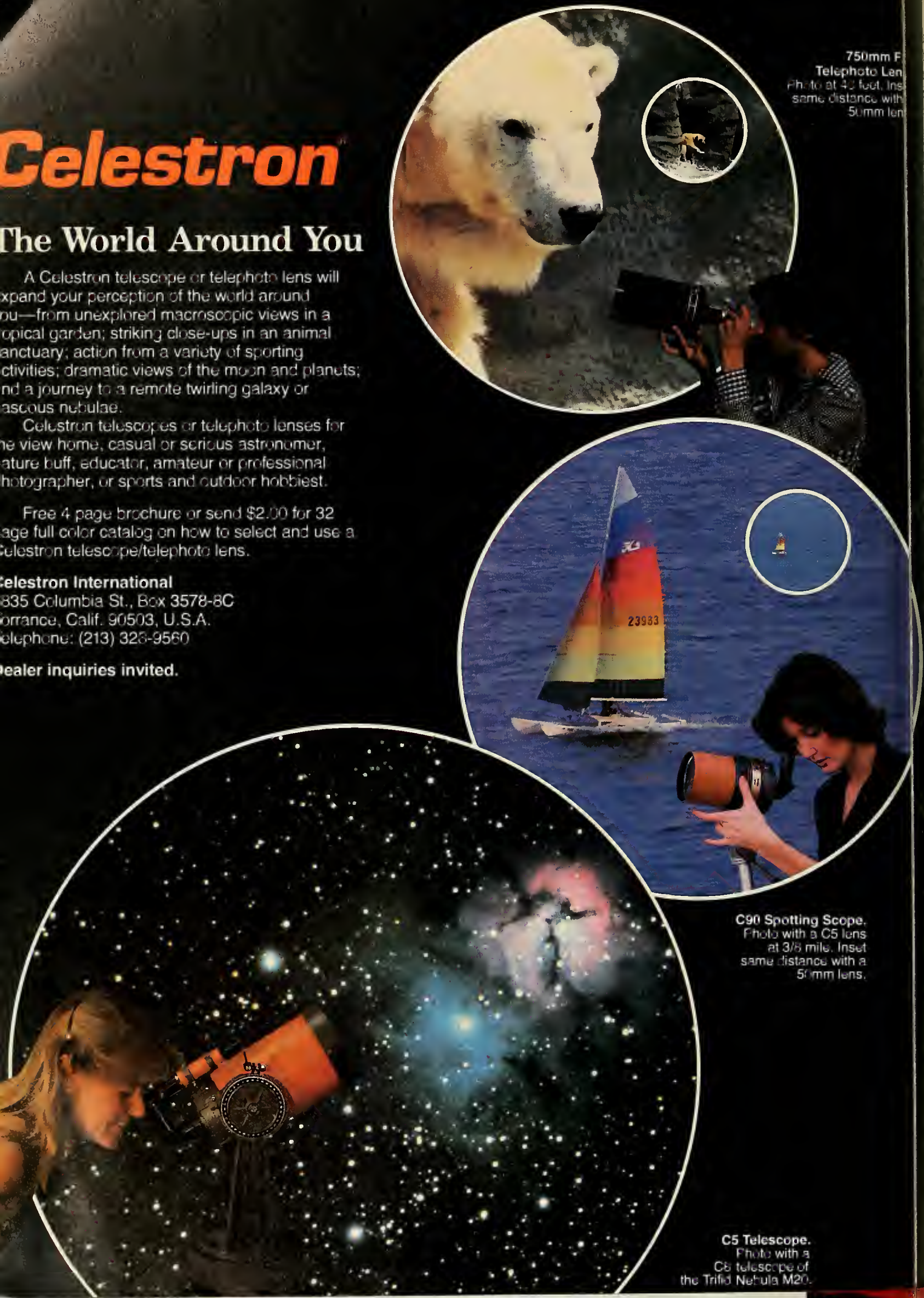
The middle air route follows the broad, lower area of the Columbia River valley on the border between Oregon and Washington, the Snake River area of southern Idaho, and the break between the southern and northern Rockies represented by the basins of Wyoming. This route is at a latitude near that of the maximum westerlies—about 40 degrees north. Its mild, dry airstream flows eastward roughly parallel to the Union Pacific Railroad route and can often be traced as far eastward as Ohio and Pennsylvania. This dry airstream coincides with the most easterly extension of the western grasslands.

The northern Pacific air route



*The upper treeline is largely determined by temperature; the lower one by dryness. As the airstreams flowing across North America shifted from one century to another, the northern forest underwent dramatic changes. Above is a contemporary woods on the edge of the prairie in South Dakota.*

*A prairie preserve in northwest Iowa, left, on the edge of the Great Plains, looks like this today. Over the centuries, the plains have changed from riparian woodlands to steppelike stretches having few trees to a "sea of grass."*



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across the Canadian Rockies has no broad system of passes through which the lower-level air can flow. But the relative ease of vertical movement of the Pacific air at Canadian latitudes, combined with the strength of the westerlies, makes it possible for rather low-level Pacific air to cross the mountains. This air is mild for its latitude, even in winter, and is, of course, dry.

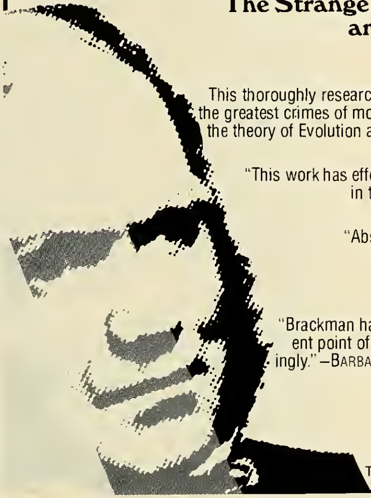
The eastern half of North America, with its broad Hudson Bay-Mississippi Valley system of lowlands is open to the unimpeded flow of cold arctic air southward and of warm, moist tropical air northward. Between these two extreme types of air, the west winds drive a wedge composed of the three modified varieties of Pacific air.

The seasonal dominance and interplay of all five of these air types defines the climatic regions of North America and puts controls on the distribution of plant and animal life. The variation in length of time the various airstreams dominate in a given area is at the heart of climatic change.

On special occasions when the west–east airflow overtops the mountain ranges, it undergoes compression, heating, and drying as it sinks down the leeward slopes, and a dramatic, intense chinook—a warm, dry wind—occurs. Of a milder nature but broader scale, the three Pacific airstreams also undergo warming and drying as they descend to the Great Plains. Together, these air masses set the climatic pattern of the American West.

The depth of penetration of southern and western moisture-bearing airstreams has varied in the past, causing changes in the amount of water available to the rain- or snow-bringing meteorological processes. The spilling of cold airstreams into the topographic basins of the Cordilleras has also caused widely felt changes that influenced the character of the West in earlier times and continues today to affect water supplies and agricultural practices in areas traditionally short of water.

In early summer, at about the end of June, the west winds of the mid-latitudes shift northward and contract into a smaller vortex around the North Pole. With this change the moist tropical air penetrates more readily northward over the Great Plains and extends into the southwestern United States as well. This event raises the humidity, initiates the summer rains of the Southwest, and provides midsummer showers on the northern regions of



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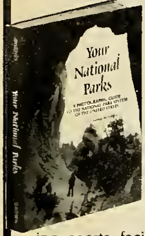

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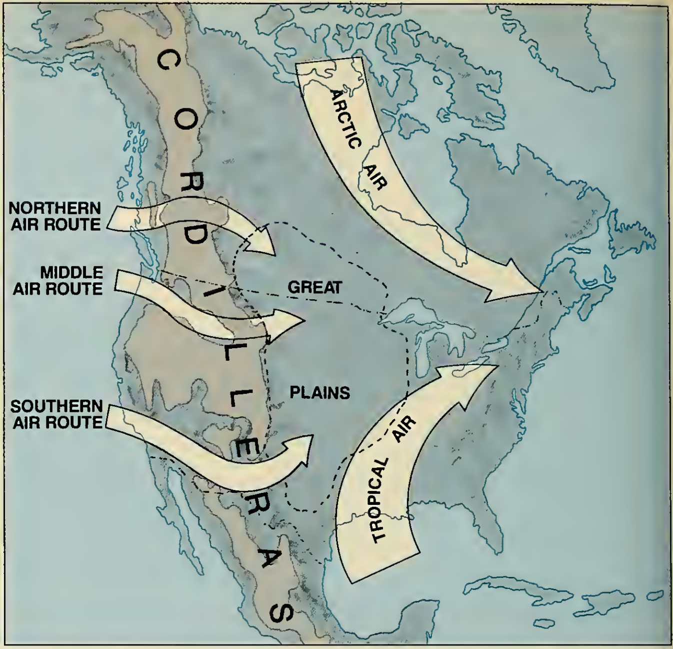
# Airflow in the American West



Joe Le Monnier

the Great Plains. At the same time the cyclonic storms of the westerlies shift northward and diminish, decreasing the rains of the Pacific Northwest and moving the warm chinook zone northward to flow across the spruce forests of Canada.

In winter, a shallow layer of cold air pours southward from the Arctic, filling the central lowlands and the plains up to about a 2,500-foot elevation, on the average, along the edge of the northern plains. The westerlies in that season are farther south than in summer and more dry air moves eastward through Wyoming and south of the Sangre de Cristo Mountains, the southernmost range of the Rockies in Colorado and New Mexico.

During relatively cool and generally more winterlike periods in earth history, the arctic air reaches farther south in summer and the westerlies are farther south and stronger. In warmer periods, the arctic air occupies a more restricted region, the westerly wedge of chinook climates is farther north, and so are the thundershowers derived from tropical air streaming northward.

The upper treeline in the United States Rockies is largely determined by temperature and the lower treeline by dryness. In similar manner, the northern Canadian treeline is bounded by year-round cold arctic air and the southern treeline by the warmth and dryness of year-round chinook-dominated air. The shifting of the airstreams from one century to another should make dramatic changes in the tundra and the northern forest and, thus, in the economic base of the peoples of the Great Plains.

I acquired personal knowledge of just such past environmental changes serendipitously in the early 1960s when my field partner, Robert Ragotzkie, a biologist-meteorologist-oceanographer at the University of Wisconsin, and I were exploring fossil soils over an area in excess of 150,000 square miles in and north of Manitoba, Canada.

In the course of our investigations, and those of some colleagues, we uncovered soils that recorded north–south movements of about 200 miles in the northern forest border along the line from Churchill, Manitoba, to Great Bear Lake in Canada's Northwest Territories. Radiocarbon dating of the soils showed that more than 3,600 years ago the forest was far north of its present limit. It subsequently retreated abruptly southward (to approximately its present position) 2,000 years ago. By the late twelfth century, it had advanced fifty to sixty miles north. A second, abrupt southward shift of the forest border in about 1200 indicated an expansion of the realm of arctic air that brought a change in the pattern of the westerlies farther south.

Data from various other sources corroborate the story of the fossil soils. The extent of sea ice and cold-induced famine years in Iceland, written records from Europe, pollen data from the Midwest, and glacial data from Switzerland all record the occurrence of cooling at the high latitudes and a southward shift of the westerlies about the year 1200.

With the use of modern data, David Baerreis, an anthropologist from the University of Wisconsin, and I reconstructed past summer rainfall changes in the United States that should have accompanied the increased strength of the summer westerlies in mid-latitudes. The reconstruction indicates that a slight expansion of the arctic area, combined with a slight increase of the westerlies in the latitudes of the United States, produces a dramatic decrease of midsummer rainfall in the northern and central regions of the Great Plains, the Northwest, and large areas of the Southwest. The reconstruction also shows more rainfall along the West Coast, but even a doubling of July precipitation in that region still doesn't represent much rain.

To verify our theory of what might have happened in the twelfth century, Baerreis and I undertook a series of excavations of Indian sites of the Mill Creek culture in northwestern Iowa, where villages appeared to be occupied after 1200. Despite the use of several types of data—plants, seeds, and pollen, for example—from a number of sites, the evidence consistently pointed to a substantial environmental change from prairies with riparian woodlands to steppelike conditions with far fewer trees. Investigation of garbage pits indicated that the meat diet of the Mill Creek villagers also changed, with a dramatic decrease in the consumption of deer—a woodland browser—and an increase in the consumption of bison—a short-grass grazer.

Our study concluded that the twelfth century marked the beginning of a two-century-long period of frequent, severe drought in the northern regions of the Great Plains. On the high parts of the plains, always more marginal for agriculture, the drought terminated the life style of prehistoric Indian tribes of the area. Farther east the Mill Creek people managed to last through most of the next two centuries, but with the strongly modified subsistence base already mentioned.

Our reconstruction also showed a complex pattern of changed rainfall in the Southwest, where numerous studies strongly indicate a disruption in the occupations of inhabitants, reduction of the area occupied, and a strong cultural modification in the twelfth and thirteenth centuries. The cultural changes included a switch from stone to adobe pueblos, as prehistoric peoples moved from canyons to broad valleys like the Rio Grande; a noticeable difference in ceramic styles; and the disappearance of the Great Kiva, a structure used for ceremonial purposes.

This account of some investigations of the thirteenth century contains a message for the future. The rainfall pattern of July 1974 (and of other recent years) had a strong similarity to the pattern of the thirteenth century. Since what has happened once can happen again, we must seriously consider whether we are at the beginning of a very long period of drought or at the end of a short period.

The droughts of the thirteenth and fourteenth centuries left the American West changed in ways that are perceived today. For example, nomadic hunters largely replaced the western villagers of the previous time. Many of the new inhabitants were Athabascans—northern people—as might have been expected with the expansion of the Arctic. The Pueblo cultures of the Southwest had also changed. The great period of the Anasazi, or Basket Makers, and of other Indian cultures such as the Mogollon was over and their area of occupation was drastically reduced. Only the Hohokam, who lived in the semiarid region of what is now central and southern Arizona and who practiced irrigation, continued in about the same numbers as before the droughts.

At about the beginning of the seventeenth century, another hemispheric climatic change occurred. The first step in hemispheric cooling, after the medieval warm period of about 900 to 1200, had occurred at about the begin-

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ning of the thirteenth century. The second step into the "Little Ice Age" (from the thirteenth to the twentieth centuries) was largely completed immediately prior to 1600. Arctic ice expanded; many glaciers grew in such places as Iceland, Ellesmere Island in Canada's Northwest Territories, and Switzerland; the price of wheat in Europe skyrocketed; and the American West was changed climatically. We can be fairly specific about certain features of this new climatic situation because it continued into the period of scientific observation—the early 1800s—and did not end until about the beginning of the twentieth century.

To understand the changes that occurred during the Little Ice Age, we must consider a few more details of atmospheric behavior, particularly the development of the north–south meandering of the high-altitude westerly winds. When the Northern Hemisphere chills, most of the cooling takes place in the Arctic and sub-Arctic. This cooling is associated with a southward expansion of the west winds toward the equator, similar to the expansion of 1200. Additional southward movement of air masses, with further cooling, extends the west winds far enough into the tropics to produce a phenomenon called dynamic instability, in which the upper-level west winds, instead of flowing eastward with gentle north–south undulations, frequently break into great loops. These loops may carry tropical air far north into the Arctic and arctic air far south into the tropics.

From the point of view of climate, the most important attribute of these big loops of air is that they are slow-moving. Meteorologists often refer to their effects as "blocking." (The term is something of a misnomer since the loops don't actually block anything, but storms do not usually pass through them.) We know from both reconstructions and direct scientific observation that such situations were far more common during the Little Ice Age than in the twentieth century.

These blocking loops tend to be preferentially located in certain geographical areas—a northward loop, for example, located over the Cordilleras—resulting in the development of strong west–east contrasts of climate.

By the time the wave of European emigrants reached the Great Plains in the nineteenth century, conditions there had changed from those that had characterized the thirteenth and fourteenth centuries. Instead of the drought that had terminated corn agriculture over a wide area, the Great Plains had up to 30 percent more rainfall than in the modern era. North of Texas, the plains were cooler than at present in all seasons, but the Great Basin, west of the Rockies, was warmer. The rainier, cooler climate on the plains supported a "sea of grass," which, in turn, supported enormous herds of bison. (These large animals, more commonly known as buffalo, once numbered in the multimillions. They roamed over vast areas of North America in huge herds and were hunted by American Indians for their meat and hides, which were used for tents, blankets, and clothing. Nevertheless, the animals flourished until the westward migration of the European emigrants, who hunted the bison almost to extinction. By 1900 few of the animals were left.)

The increased rainfall, in both summer and winter, of the nineteenth century raises an obvious question: Why didn't the return of precipitation following two centuries of drought restore to the Great Plains the rain-nourished corn agriculture that had flourished there seven centuries earlier? I don't know the answer, but I suspect that part of it may be the sluggish behavior of the weather during periods of atmospheric instability and of block-

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ing. We know that such periods are characterized in the Great Plains by both weeks of intense drought and weeks of heavy rain. The drought increases the chance of widespread grass fires; the heavy rains tend to make corn farming hazardous. Photographs from the last decades of the Little Ice Age show far fewer trees, in general, on the plains than during the period from 1930 to 1960, despite measured rainfall quantities greatly in excess of that later period.

As the Europeans moved west, resettling the regions abandoned by the Indian farmers of seven centuries earlier, leapfrogging to the West Coast and pushing into the mountains, the climate once again started to change. The Little Ice Age was ending.

Western climatic data of the 1850s period show that Taos, New Mexico, had about the same summer rainfall then as Madison, Wisconsin, has now. I live in Madison and I know that if I didn't mow my lawn all summer long, it would grow to be "stirrup high," as the grasses of the West were often described in the central high regions and parklands of the Great Plains. If we consider the carrying capacity of grasslands for bison to be proportional to that for cattle, we can then estimate the impact of the 20 to 30 percent decrease of precipitation in the Great Plains that occurred between the 1850s and the 1930–1960 period.

Using rough estimates of carrying capacity as related to rainfall, we might find that, with fifteen inches of rainfall per year, a particular range area in good condition would just support five animals. If the rainfall should decrease to ten inches per year, a percentage change that occurred over large areas in the late 1800s, the range would be overstocked, for with that rainfall, even range in good condition could only support two to three animals in the same given area. The condition of the range would thus deteriorate to an average carrying capacity of one animal on an area that once held five.

All other factors being constant, such a diminution of carrying capacity would have reduced the bison herds by about three-quarters—but other factors weren't constant. Intense hunting took place at the same time that the herds were at serious risk because of climatic change, and the combination eliminated the bison as an important food source in the Great Plains.

Farther east on the plains the extension of chinook climates affected grain farming. Wheat yield in Ellis County, in central Kansas, dropped from about fifteen bushels per acre in the 1870s to about nine in the 1890s, while corn yields dropped from about thirty bushels per acre to about twelve. If we chose one year to mark the end of the wetter era on the Great Plains, it would probably be 1883.

Data show that our perception of the western section of the Great Plains as a sea of grass supporting enormous herds of the grazing animals hunted by horse-riding nomads was only a snapshot of a transient piece of American history. So was the estimate of how many acre-feet of water in the Colorado basin could be divided up among potential users.

These perceptions would be interesting bits of lore except for the incorrect but widely held theory that climate does not change or changes so slowly that humans can always adjust. The study of western environmental history shows that the nature of the American West is closely tied to its varying climate. The facts are clear that the western climate changes significantly, sometimes rapidly, and may stay changed long enough to change the character of human cultures.

Coupled with our myths about climatic stability is our current image of ourselves as technologically self-confident if not perhaps even invincible. Whatever the contingency, whether it be flood, drought, food shortage, or environmental pollution, our technological genius will prevail.

But will cloud seeding really break a drought due to the prevalence of extended, cloudless skies and dry chinook air? Can irrigation canals, dams, and pump storage increase the normal flow of the Colorado River for apportionment? These are questions we must face up to.

As the future population and use of the American West push against the carrying capacity of the land, climatic variations will become more critical. As world population increases, the role of the West in food production likewise will become more critical. One of the few near certainties about the future is that the climate will continue to vary, as it has in the past, and the variations will doubtless again alter the economic base of the region.

Will we face the future armed with facts or encumbered with quaint perceptions and false theories? ☐

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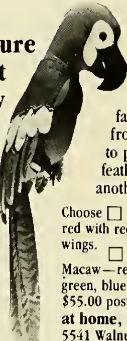

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# Celestial Events

by Thomas D. Nicholson

**The Moon** The evening moon shows up as a slender crescent in the west after sunset about June 15. First-quarter follows on the 20th and full moon on the 28th, when the moon is up from sundown until sunrise. In early and late June, the moon rises after dark and remains in the sky past dawn. Last-quarter is on June 5, new moon on the 12th. Phases in July are: last-quarter on the 5th, new moon on the 12th, first-quarter on the 20th, and full moon on the 27th. Perigee moon (nearest the earth) occurs on June 8 and July 4 and 30; apogee (farthest from the earth) on June 21 and July 18. Occultations by the moon include Aldebaran (June 11 and July 9), Regulus (June 17 and July 15), Jupiter (June 18 and July 15), Saturn (June 19 and July 17), and Venus (July 9), but most are unfavorable for North American viewing.

**Stars and Planets** From the 11th to the 15th, all the planets are evening stars, above the horizon at sunset. More important for viewers, all five bright planets (visible without a telescope) are favorably placed for evening viewing in the first week of June. Venus is past its prime but still bright and high enough to be easily seen low in the west after sundown. Mercury is right next to it on the 1st, still close on the 2nd and 3rd. By the 5th, Venus may be too low at sundown; Mercury holds its position past midmonth, although it is fading rapidly.

The planets that gathered in Leo this winter, Jupiter, Mars, and Saturn, are still there but are now well spread out in the southwest after dark. The moon moves past them from June 17 to 19 and July 15 to 17. Mercury remains in Gemini in June; Venus retrogrades from Gemini to Taurus; Mars, Jupiter, and Saturn are in Leo; Uranus is in Libra; Neptune in Ophiuchus; Pluto in Bootes. The sun moves from the constellation Taurus into Gemini.

June 1: Mercury is quite close to Venus tonight.

June 11: The daytime occultation of Aldebaran is above the horizon along the West Coast.

June 14: Mercury, near the moon tonight, is at greatest easterly elongation, well placed as an evening star.

June 15: Venus, in inferior conjunction, becomes a morning star.

June 17: The moon is quite close to Regulus tonight. Jupiter, Mars, and Saturn are to its left.

June 18: The moon is between Jupiter and Regulus, to its right; Mars and Saturn, to its left.

June 21: The sun is at the summer solstice at 12:47 A.M., EST.

June 25: Mars passes from right to left of Saturn.

June 27: Mercury begins retrograde (westerly) motion.

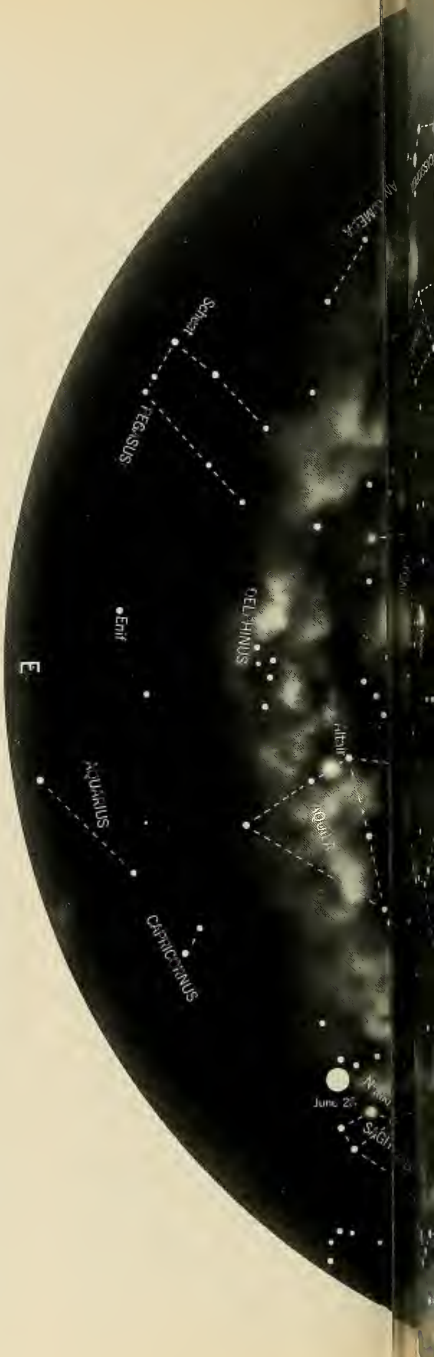
July 5: Earth is at aphelion, farthest from the sun, 152,100,000 kilometers (94,500,000 miles) distant.

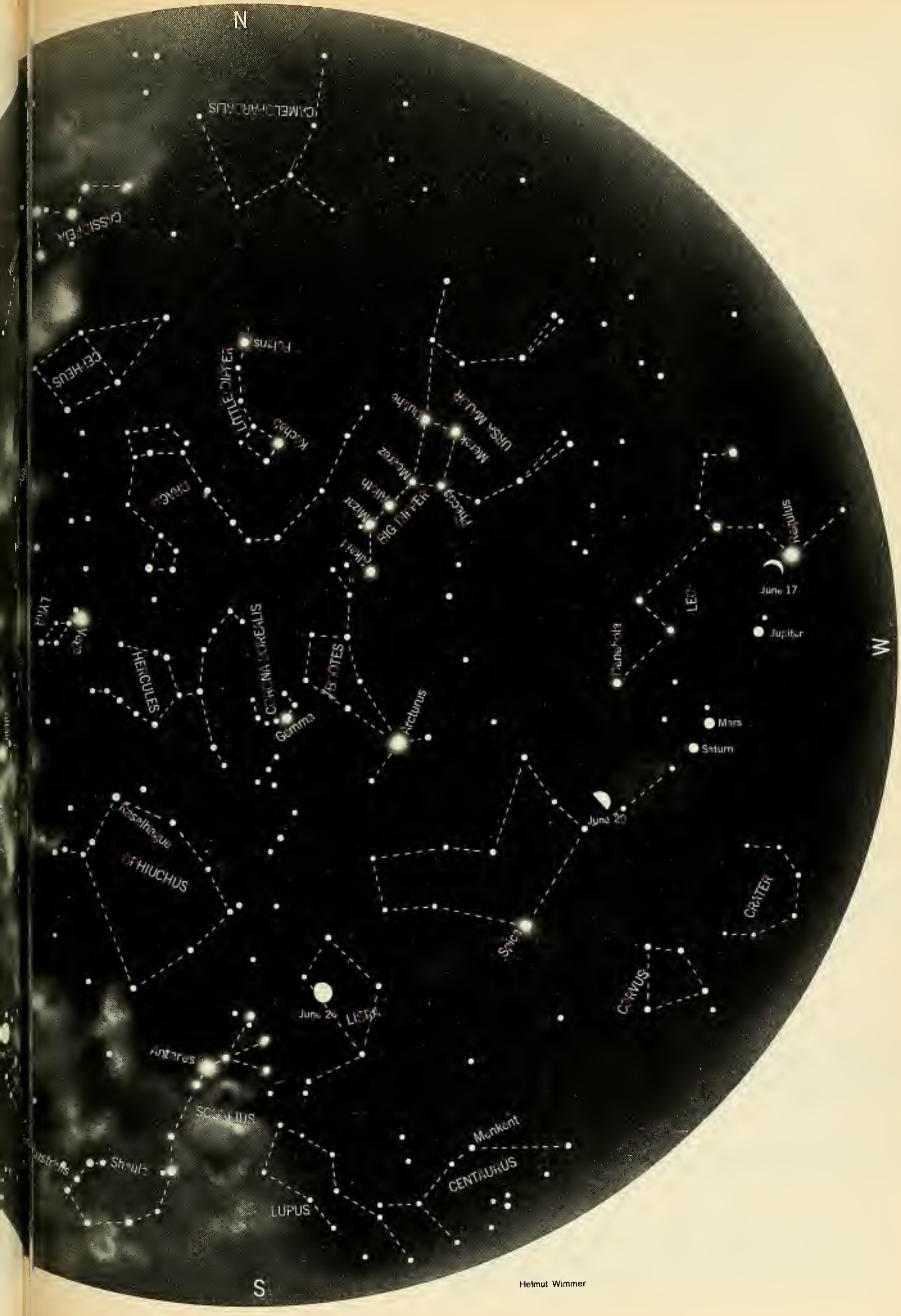
July 9: The daytime occultation of Venus occurs above the horizon in North America.

July 11: Mercury, in inferior conjunction, becomes a morning star.

July 15: An early evening occultation of Jupiter occurs above the horizon in western North America.

**Evening Star Map** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those you see in the sky. When you turn to face in other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match stars in the sky with those on the lower half of the map. The map represents the evening sky at about 11 to 12 P.M. on June 1; 10 to 11 P.M. on June 15; 9 to 10 P.M. June 31; and 8 to 9 P.M. on July 15. Only planets and moon phases above the horizon at those times are shown. All times are EST.

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# Afterworlds in the Attic

No one really knows exactly how many artifacts are in the anthropological collections of the American Museum of Natural History. But whatever the number, they fill to overflowing some fifty storage rooms, vaults, and attics scattered throughout the Museum's twenty-two buildings. The physical objects, however, constitute only a portion of the entire collection. In the past 111 years, Museum ethnographers have assembled another kind of collection that is, in a sense, invisible. It has no catalog numbers, is not cross-referenced, and has no monetary value. It cannot be displayed, photographed, or insured.

This collection is a vast body of myths, songs, dreams, and visions garnered from hundreds of living and extinct cultures from New Guinea to Manhattan Island. Both in published works and in reams of unpublished notes stored in a fifth-floor vault, one can find hundreds of creation myths, descriptions of afterworlds, epic tales of gods, humans, and demons, magical formulas, dreams, songs, and chants. Hidden among these books and papers is a version of the creation of man from the Hackensack Indians of Staten Island, along with accounts of the dream cults of the Oglala Sioux and shaman chants of the Tsimshian. Here too one can read the European-influenced epics of the San Carlos Apache, the love poetry and death songs of the Ojibwa, and dozens of myths of the Great Flood and stories of the golden age when animals spoke like people.

According to David Hurst Thomas, chairman and curator of the Department of Anthropology, no one has any idea of just how much—or what—mythological material might be stored in the Museum. "The Museum," he says, "hasn't consciously compiled and sorted the material. All I can tell you is that there's a hell of a lot of it. But it's the kind of thing that falls through the cracks, if you know what I mean."

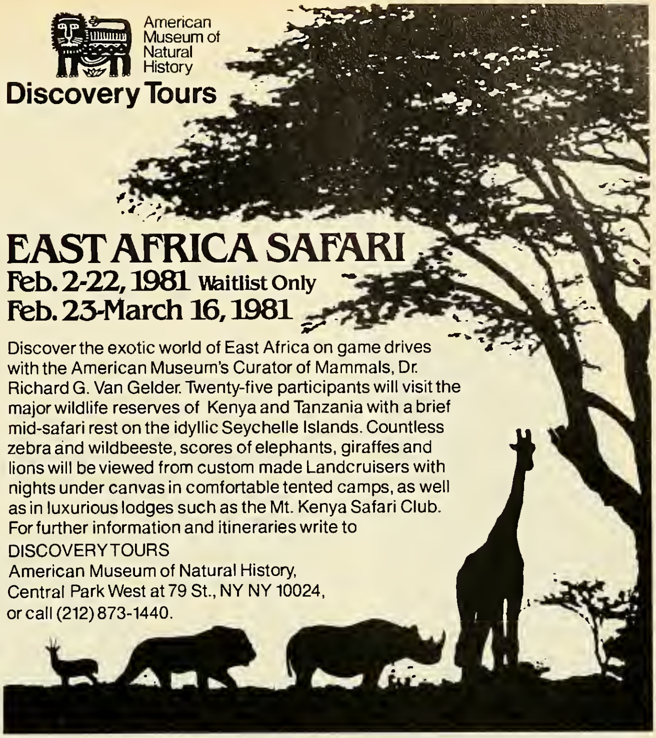
Thomas explains that the Museum gathered most of its mythological material before 1930. Today, with a few exceptions, Museum ethnologists are less interested in mythology, partially because many of them are working in "literate" societies, where myths are written down. One of the exceptions is Robert Carneiro, a curator specializing in the cultures of Amazonia. In a visit to South America in 1975, he collected a dozen myths from the Kuikuru, a Carib-speaking people who live in a single village in the upper Xingú basin of central Brazil.

By far the most complete body of myths collected by the Museum has come from the Indian cultures of North America. Between 1880 and 1930, assiduous myth collectors traveled west with pen and paper to capture the Indian myth cycles before they became hopelessly garbled by

Christian influences. While Franz Boas was busy recording the entire mythological system of the Kwakiutl in the original Kwakwala, first for the Museum and later for Columbia University, his contemporary Robert H. Lowie was tramping across the West from Alberta to Arizona, collecting hundreds of myths (as well as artifacts) from the Hopi, Assiniboine, Blackfoot, Cree, Shoshoni, and Ojibwa cultures. Pliny Earle Goddard, another Museum curator, spent twenty years studying the dancing societies of the Sarsi, the dialects of the great Athabascan family, and the ethnology of the Southwest Indians in general. Clark Wissler, who was chairman of the Department of Anthropology, built the Museum's collection of Indian material into one of the finest in the world and also edited several numbers of the *Anthropological Papers of the American Museum of Natural History*, in which many of the myth cycles were published.

Boas was one of the first anthropologists to recognize the scientific value of myth. In the preface to his *Kwakiutl Culture as Reflected in Mythology* (1935), he wrote that through a people's myths, "a picture of their way of thinking and feeling will appear that renders their ideas as free from the bias of the European observer as possible."

Myth gathering, Boas realized early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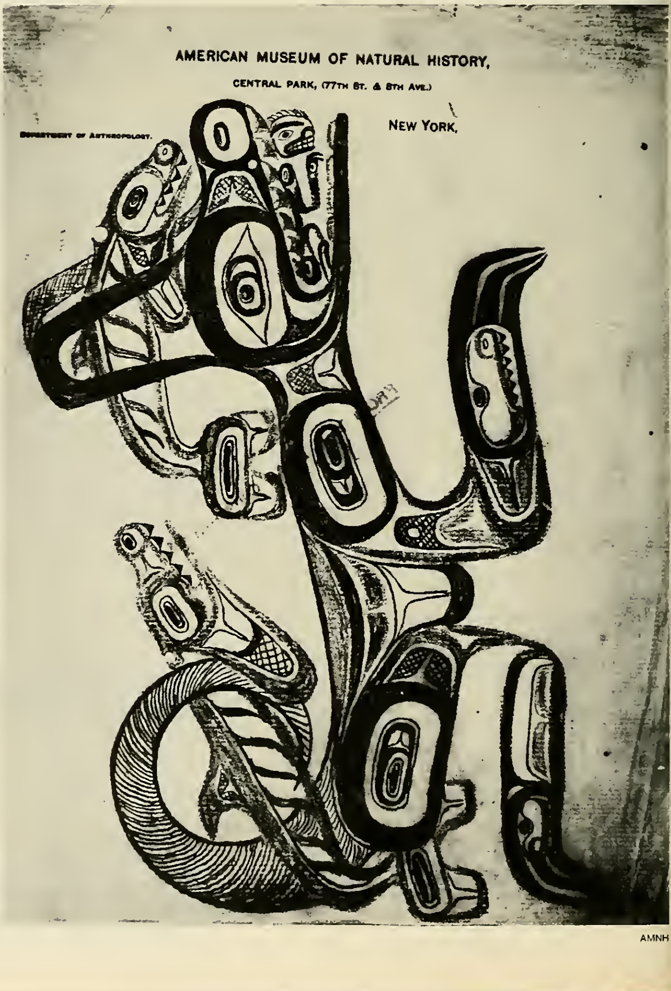
in his career, was not easy, as an entry in one of his early journals attests:

> October 12. I had a miserable day today. The natives held a big potlatch again. I was unable to get hold of anyone and had to snatch at whatever I could get. Late at night I did get something [a tale] for which I had been searching—"The Birth of the Raven". . . . It is especially curious that myth cycles do not seem to be alike among the different tribes speaking the same language, although I am not sure how much of this may be due to my ignorance of the myths.

When Boas was not in the field, his interpreter, George Hunt, agreed to collect and transcribe Kwakiutl myths, for which Boas paid him 50¢ a page. Morris K. Jesup, the first president of the Museum, reimbursed Boas for this worthwhile expense.

Lowie and Wissler faced a different set of problems. Many of the myths they recorded involved lesbianism, necrophilia, bestiality, coprophagy—subjects that would have shocked a culture only recently emerged from the Victorian Age. The Museum, following a standard practice, solved the problem of publishing this material by translating the sensitive passages into classical Latin, which, presumably,

*Apparently Boas had run out of blank paper and had to use a piece of American Museum stationery for this drawing of the mythological sea wolf with two killer whales sporting behind its back.*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only an erudite and dedicated scholar could decipher. The result was often an odd mixture of languages:

> "Lignum Mentulae Vice Fungens"
> A hunter heard someone laughing. Prope risores cum advenisset, duas mulieres conspexit quae ridentes ligno pro mentula utebantur. The woman caught sight of the man and broke the piece of wood ita ut utrius—que earum vulvae dimidium haereret.
>
> —Assiniboine, 1907

In other texts, Museum authors and editors prepared a carefully censored and circumspect translation for the beginning of the paper and put the undoctored text at the end as a word-by-word, unsyntactical translation next to the original Indian text.

Since the 1930s, the Museum gradually shifted its focus from myth collecting and interpretation to other aspects of human culture. Myth, however, will continue to fascinate and attract anthropologists. "I became interested," says Robert Carneiro, "in the Kuikuru myths as narratives, almost on a subscientific level." Gathering the myths of the Kuikuru turned out to be easy. Unlike some groups who delight in lying to anthropologists (who, after all, are an ideal target), the Kuikuru are truthful and do not feel that myths and beliefs are secret knowledge to be guarded from outsiders. Carneiro was able to find several older informants who knew a great deal about myth, the soul, and the afterworld and who were happy to have an attentive audience.

Among the Kuikuru, the learning and transmission of myths and beliefs is a casual matter. "Now and then," says Carneiro, "someone will tell a myth and those who want to listen will gather around. But there is no concerted effort to teach the young the mythology, and some adults don't know the myths and aren't particularly interested."

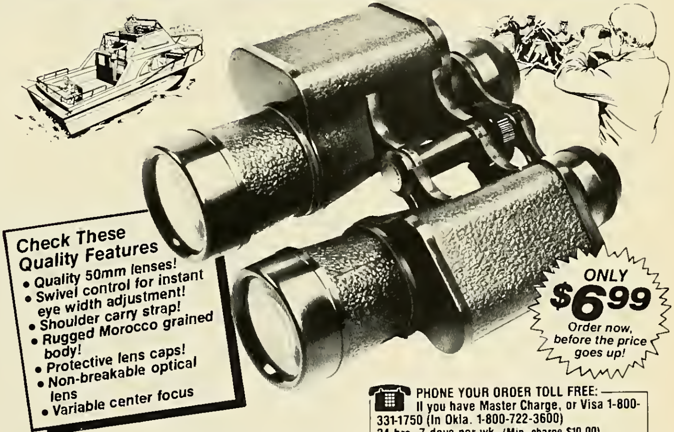
Carneiro feels the study of myth has its limits. "I tend to be skeptical of efforts to interpret myths. And to think you can decipher the basic nature of the human mind from myth—as in the work of Lévi-Strauss—strikes me as going too far." Myths, Carneiro feels, are in some respects much like material objects and can be a means of elucidating relationships between cultures. "If we had," he explains, "a full corpus of myths from every tribe in Amazonia, we could reconstruct contacts and influences."

Of the dozen or so myths Carneiro collected, one is in press, and the rest he hopes to publish together in the *Anthropological Papers of the American Museum of Natural History.*

The Museum's collection of myths may turn out to be as valuable and irreplaceable as its physical collections. Artifacts can survive the extinction of a culture: pots, house foundations, knives, stonework, and burials will last for thousands of years. The myths of a nonliterary culture, however, are perhaps its most delicate artifact and are the first to disappear in the face of change or destruction. It was perhaps with this thought in mind that Franz Boas addressed the Kwakiutl in 1897 with the following words:

> Friends, I am Mr. Boas who is speaking to you. I am he whom you called Heiltsaqoalis. It is two winters since I have been with you, but I have thought of you often. . . . I am sorry to see how many of your children . . . walk the ways of the white man. The ways of the Indian were made differently from the ways of the white man at the beginning of the world, and it is good that we remember the old ways . . . your young men do not know the history of your people . . . it is not good that these stories are forgotten. . . .

*Douglas J. Preston*



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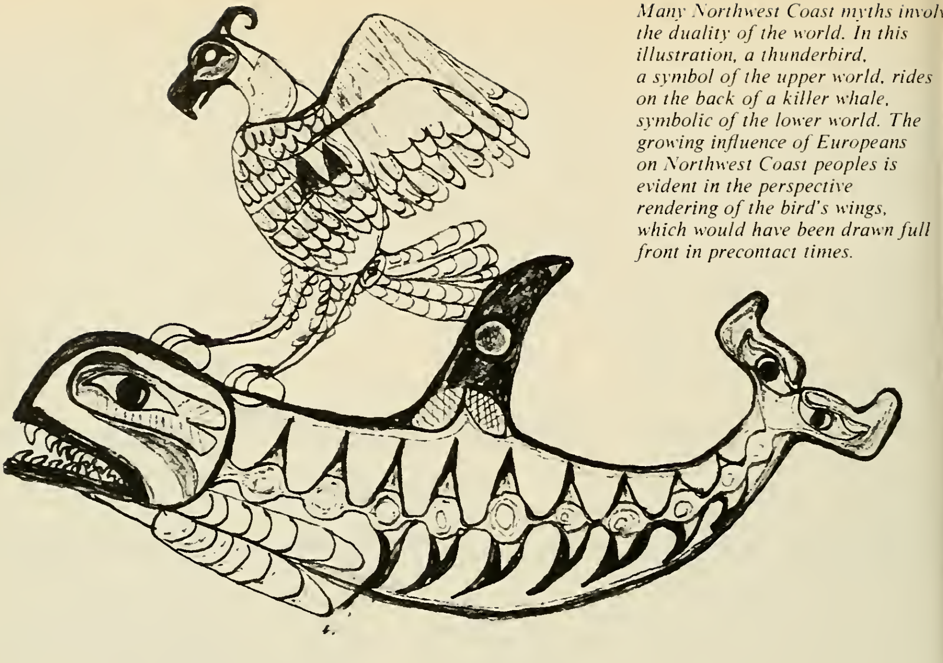

*Many Northwest Coast myths invol the duality of the world. In this illustration, a thunderbird, a symbol of the upper world, rides on the back of a killer whale, symbolic of the lower world. The growing influence of Europeans on Northwest Coast peoples is evident in the perspective rendering of the bird's wings, which would have been drawn full front in precontact times.*

AMN

**Objects of Bright Pride**

The Membership Office is presenting a special members' series, *Native Americans of the Northwest Coast*, on two Wednesday evenings, June 18 and 25 at 7:30 P.M. in the Auditorium. The first program will feature Edward S. Curtis's *In the Land of the War Canoes*, filmed in 1914, with a Kwakwala-language soundtrack added in 1973. Bill Holm, who produced the soundtrack, will introduce the film and answer questions from the audience.

The second program, *Objects of Bright Pride: The Formation of a Great Collection*, will be a lecture by Alan Wardwell on the formation of the Museum's collection of Northwest Coast art, judged by many to be the largest and finest in the world. The lecture will include slides of artifacts, and nineteenth-century transparencies of the Northwest Coast taken during expeditions there. Wardwell is director of the Asia House Gallery and curator of *Objects of Bright Pride*, an exhibition of Northwest Coast art from the Museum collection now on display at the Center for Inter-American Relations in New York. The programs are free to members, $3.00 each for nonmembers.

**Discovery Tours**

In June 1980, twenty-five friends of the Museum will join Kenneth A. Chambers, lecturer in zoology at the Museum, for a three-week *Alaska Wildlife Adventure*. The trip will explore several different habitats in search of wildlife. At Glacier Bay, where glaciers meet the sea, tour members will observe hair seals and whales amidst newly created icebergs. In Mount McKinley National Park, tour participants will search for mammals and birds in the wildflower-covered tundra at the base of the Alaska Range and Mount McKinley. Tour members will fly across the Bering Sea to the Pribilof Islands, where more than a million fur seals and countless rare cliff-nesting birds can be found. Write to Discovery Tours for more information about the *Alaska Wildlife Adventure* and other 1980 and 1981 tours.

**Shadow of Vishnu**

Puppeteers, musicians, storytellers, shadow puppet artists, and others from India will present ten performances of traditional puppet theater June 17–22. The maharajah of Sawantwadi will introduce and explain the troupe. The puppets—some beautiful, some grotesque—represent gods and demons, heroes and villains, and other mythical characters featured in the ancient Indian epics. Write to the Department of Education at the Museum for more information.

**Imaginary Worlds**

Twenty watercolors by artist Sonja Eisenberg are currently on display at the Hayden Planetarium. Eisenberg, who has had showings in New York, Paris, Amsterdam, and other cities, paints visions of imaginary worlds. The show, entitled *New Horizons*, will continue through June 16.

**Aztec Theater**

The Touchstone Center, known for its unusual theatrical productions based on anthropology, will present *My Music Reaches to the Sky*, a piece about an Aztec myth. The free performance will take place in the Education Hall on Saturday, June 14, at 1:00 and 3:00 P.M.

**Northwest Coast Film Series**

On June 7 and 8, the Department of Education is presenting films on the Indians of the Northwest Coast. On Saturday, June 7, four films exploring traditional Northwest Coast art and culture will be shown in the Auditorium between 2:00 and 4:20 P.M. Included will be anthropologist Franz Boas's 1930 film, *The Kwakiutl of British Columbia*, made on his last trip to the Pacific Northwest. On Sunday, June 8, between 2:00 and 4:00 P.M., two films will deal, respectively, with Indian photographer Edward S. Curtis and the mythology of the totem pole. All films are free.

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# The Birds and Beasts Will Teach Thee!

### by Faith McNulty

MR. PEALE'S MUSEUM, by Charles Coleman Sellers. *W. W. Norton and Co., $14.95; 370 pp., illus. A Barra Foundation book.*

Recently a friend of mine visited the Grand Canyon. He told me that he had not been tremendously stirred by the experience, but that the expression on the face of his dog as it peered into the abyss was worth the price of the trip. Reading *Mr. Peale's Museum* I was reminded again of how much of our ability to marvel has been lost and in what a short time. It is not quite a hundred and eighty years since Charles Willson Peale undertook this country's first organized scientific expedition for the purpose of exhuming "The Great American Incognitum"—the bones of what proved to be a mastodon discovered in a marl pit on a farm near Newburgh, New York. The event caused national excitement. President Jefferson offered the army's help to get the bones out of the water-filled pit, but improvisation and invention came naturally to Peale. He devised his own ingenious machinery—a wheel turned by the leg power of eager volunteers brought up buckets of water and drained the pit at the rate of 1,440 gallons of water an hour. Peale later wrote in his diary, "The Vice President [Aaron Burr] and a considerable number of Ladies and Gentlemen came to see the Bones . . . . The news of them must have blew like wild fire, for upwards [of] 80 persons . . . came that evening."

When Peale exhibited the mounted skeleton in his museum in Philadelphia in 1801, the creature was hailed as the "largest of terrestrial beings," and the ninth Wonder of the World. The word "mammoth" burst into the language as "atomic" has in our day. A Philadelphia baker sold "mammoth bread." In Washington a "mammoth eater" consumed forty-two eggs in ten minutes, and a Massachusetts committee sent President Jefferson a "mammoth" cheese that weighed 1,230 pounds. Visitors thronged Mr. Peale's museum to view the giant bones ("every evening illuminated by lamplight until 10 o'clock") and must have shivered with wonder and excitement as they read a handbill describing the animal in life. According to Indian legend, "the Pines crashed beneath their feet; and the Lake shrunk when they slaked their thirst . . . . Forests were laid waste at a meal . . . . " What an animal! What a thrill to see it for the first time! It is impossible not to envy those spectators whose sense of the marvelous was still virgin and intact.

The museum was the creation of Charles Willson Peale, born in 1741, nine years younger than George Washington. Washington visited the museum and contributed two Chinese golden pheasants, which Peale preserved and mounted. "I was richly repaid in being able to preserve so much beauty. Before this time I had thought those birds . . . seen in Chinese paintings were only works of fancy." Two hundred years ago even a pheasant was still a marvel.

When Peale began collecting for his museum in 1784 he was in his forties, a veteran of the Revolution, and an established portrait painter, but painting barely supported his growing family. A commission to sketch a collection of gigantic bones—the great scientific mystery of their time—led to the thought of a museum to display similar objects and bring together examples of everything—animal, vegetable, and mineral—that makes up the natural world. To house it, Peale added rooms to his existing portrait gallery and announced in the newspapers that "Mr. Peale . . . will make a part of his House a repository for Natural Curiosities." His appeal for donations of specimens brought them by the wagonload. A stable next door was converted into a zoo where living specimens—from cougars to rattlesnakes—awaited immortality. The enterprise was a remarkable home industry. Peale, helped by his sons and daughters (of which there would eventually be ten), tirelessly collected, experimented with preservatives (DO NOT TOUCH THE BIRDS. THEY ARE COVERED WITH ARSNIC POISON, read a sign), painted appropriate watercolor backgrounds, and devised natural habitat effects of a kind that are standard today but were then a controversial innovation.

Charles Coleman Sellers's biography of the museum (he has already written Peale's) makes clear that the enterprise was a labor of love, vision, and idealism that absorbed Peale's enormous energies and talents for the latter half of his long life. There had been nothing quite like Peale's museum in the world before. Contemporary collections were starkly scientific or else popular grab bags of curiosities. Peale, implementing Rousseau's ideal of teaching as a sublime ministry, designed his museum to attract, delight, and inform all comers. In an address appealing to Philadelphians for finan-

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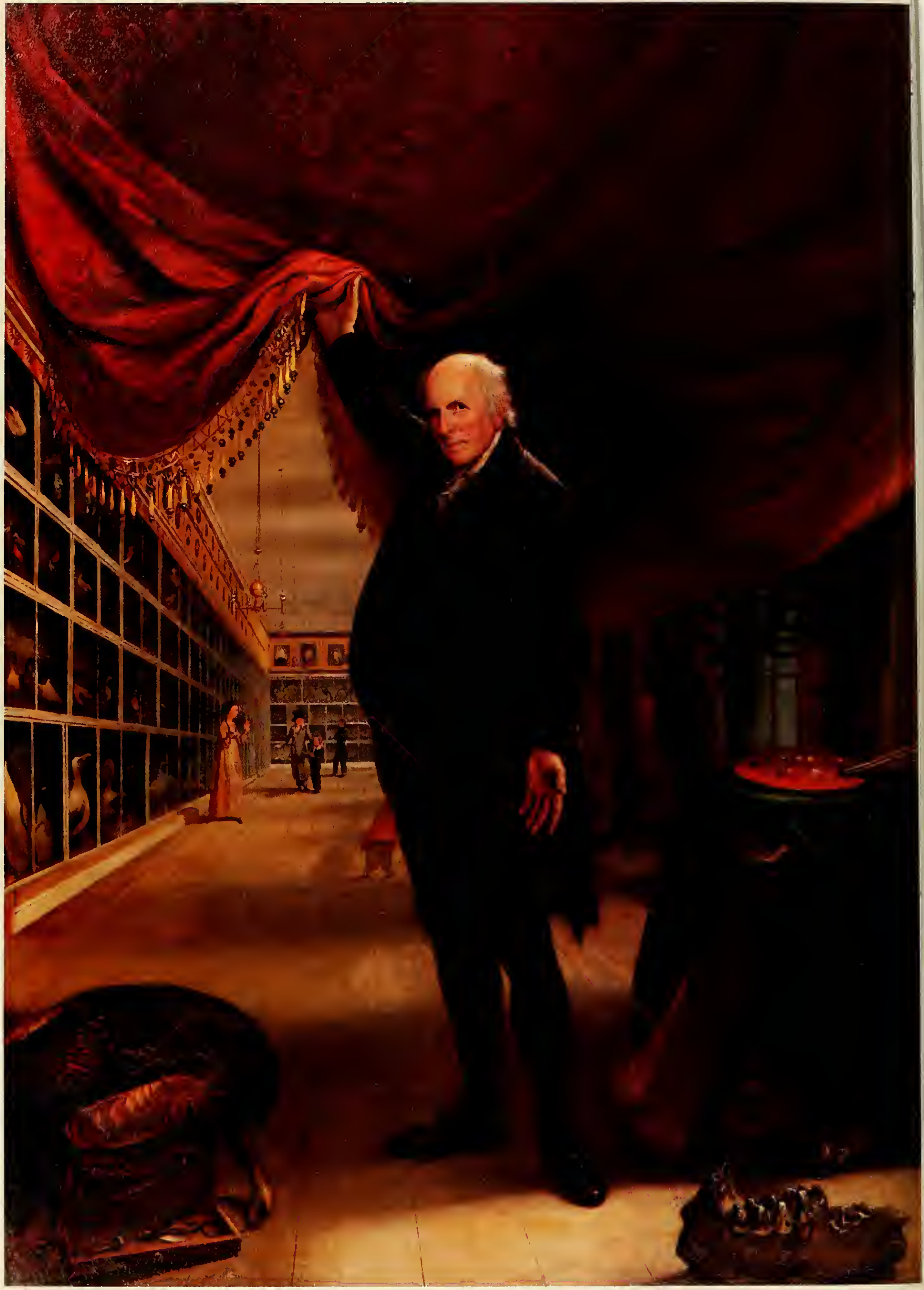

cial support, Peale described the object of his labors thus:

> To diffuse a knowledge of the wonderful works of creation, not only of this country but of the whole world. Also to show the progress of arts and science, from the savage state to the civilized man . . . . To form a school of useful knowledge, to diffuse its usefulness to every class in our country, to amuse and in the same moment to instruct the adult of each sex and age . . . did I exert every nerve by increasing labors . . . . By day and by night, as long as I could keep my eyes open, did I labour to preserve animals, common as well as those rarely met with.

Peale's belief that persons of each class, sex, and age deserved equal access to instruction was yet another of his innovations. "The birds and beasts will teach thee!" was the promise Peale printed on admission tickets that cost twenty-five cents. That the teaching might be accurate he adhered to strict Linnaean order. Of his natural history displays, his bird collection was the largest and most beautiful, and his friend Alexander Wilson based his *American Ornithology* on it, but there were also mammals, insects, fishes, minerals, and artifacts from all corners of the globe. In its heyday the museum more than fulfilled the founder's early vision.

In his old age Peale painted a portrait showing himself lifting a red velvet curtain to reveal an almost endless gallery beyond. One hand raises the curtain with a proud flourish while the other beckons the viewer to enter. The end of Peale's story gives poignancy to that beckoning gesture. From the beginning he envisioned his museum becoming a great national institute, cherished and enhanced by those who came after him. He believed that "in some future day [the musuem] will be the admiration of the world," and repeatedly begged politicians and city fathers to take it over and ensure its survival with public funds. President Jefferson thought it would be unconstitutional. The legislature thought it too expensive. Peale's offer was never accepted. After his death in 1827 at the age of eighty-six, the museum endured for another fifteen or so years, during which his many heirs struggled to wring a living from it. When they failed, P.T. Barnum gobbled up much of the contents and lost them in disastrous fires. What bits survive are mainly at Harvard, doubly valuable as mementos of an inspired lifework to which much is still owed as forerunner of the great natural history museums of today. Ironically, as Peale's museum was being dispersed, politicians were debating how best to use English scientist James Smithson's bequest "for the increase and diffusion of knowledge among men." In 1869, twenty-three years after the founding of the Smithsonian Institution, the American Museum of Natural History was chartered and would become the foremost example of Peale's ideal.

Charles Coleman Sellers, Peale's great-great-grandson, has written a book that is clearly a labor of love, filled with facts that would elsewhere be mere footnotes to history. Gathered together, they bring the reader a haunting sense of Mr. Peale's times—an era when the natural world was still inexhaustibly marvelous and numberless "wonderful works of creation" waited to be explored for the enjoyment and enlightenment of all.

*Faith McNulty is on the staff of* The New Yorker, *in which her articles on whooping cranes, whales, and other animals have appeared. A collection* —The Wildlife Stories of Faith McNulty—*will be published in October by Doubleday and Co.*

*Charles Willson Peale lifts a curtain to reveal his newly incorporated museum in this self-portrait painted in 1822.*

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**Pocket Gophers** (p. 36)

Short, readable descriptions of all kinds of pocket gophers can be found on pages 244–53 of *The Mammals of Eastern United States*, volume 2, by W. J. Hamilton, Jr. (New York: Macmillan Publishing Co., 1963). “Florida Pocket-Gopher Burrows and Their Arthropod Inhabitants,” by T. H. Hubbell and C. C. Goff (*Proceedings of the Florida Academy of Sciences for 1939*, vol. 4, August 1940, pp. 127–66), gives background on the creatures that share the pocket gopher's burrow. “Goff's Pocket Gopher,” by L. M. Ehrhart, in *Rare and Endangered Biota of Florida*, volume 1, edited by J. N. Layne (Gainesville: University Presses of Florida, 1978, pp. 1–52), provides more recent data. Two specialized articles are “Mound Building by Pocket Gophers (Geomyidae): Their Impact on Soils and Vegetation in North America,” by H. W. Mielke (*Journal of Biogeography*, vol. 4, 1977), and “Reproduction in the Pocket Gopher in North-central Florida,” by E. S. Wing (*Journal of Mammalogy*, vol. 41, 1960, pp. 35–43).

**Caterpillars** (p. 42)

The original work referred to in “Artful Diners” is described in two scientific papers by B. Heinrich. “The Effect of Leaf Geometry on the Feeding Behaviour of the Caterpillar of *Manduca sexta* (Sphingidae),” published in *Animal Behaviour* (vol. 19, 1971, pp. 119–24), discusses behavior that is nonspecific and equally adapted to a variety of leaf shapes. “Foraging Strategies of Caterpillars: Leaf Damage and Possible Predator Avoidance Strategies” (*Oecologia*, October 1979, pp. 325–37) provides many pictures of variously chewed leaves and concludes that “some caterpillar foraging behaviors may have evolved under the selective pressure of visually oriented predators that use leaf damage as a cue in their searching behavior.” H. B. Cott's *Adaptive Coloration in Animals* (London: Methuen and Co., 1940) is a review of the literature on adaptive coloration and behavior in all kinds of animals, including caterpillars. *Defence in Animals* (New York: Longman, 1975), by M. Edmunds, picks up where Cott leaves off. A summary of recent literature on the evolution and effectiveness of color and other antipredator defenses and predator-prey relationships, this book's bibliography directs the reader to original research papers, books, and review articles. *Animals and Their Colors*, by M. and P. Fogden (New York: Crown Publishers, 1974), presents these subjects for the lay reader and includes a bibliography, a glossary, and color photographs on almost every page. A. J. Alexander describes her work on heliconiid larvae in “A Study of the Biology and Behavior of the Caterpillars, Pupae and Emerging Butterflies of the Subfamily Heliconiinae in Trinidad, West Indies” (*Zoologica*, April 28, 1961, pp. 1–24). Two *Natural History* articles of interest are “Investigations into Mimicry,” by L. P. Brower and J. V. Z. Brower (April 1962, pp. 8–19), and “Mimicry: The Deceptive Way of Life,” by M. Rothschild (February 1967, pp. 44–51).

**Hail** (p. 54)

*Cloud Physics and Cloud Seeding*, by L. J. Battan (Westport: Greenwood Press, 1979), originally published in 1962 as part of the Science Study Series, discusses hail, ice crystals, rain, snow, clouds, cloud and hailstorm modification, and simulated rainfall. Also intended for the general reader, *Hailstorms of the United States*, by S. D. Flora (Norman: University of Oklahoma Press, 1956), focuses more on damage done by hail and on man's efforts to predict storms. In “The Paradox of Hail Suppression” (*Science*, January 14, 1977, pp. 139–45) D. Atlas, former director of the National Hail Research Experiment, explains how cloud seeding can either increase or decrease the amount of hail. *Hailstorms and Hailstone Growth*, by N. R. Gokhale (Albany: State University of New York Press, 1976), is a comprehensive, technical account of modern hail research.

**Wolves** (p. 58)

*The Wolves of Mount McKinley*, Fauna Series No. 5, by A. Murie (Washington: U.S. Government Printing Office, 1944), a readable account of the biology and ecology of the Alaskan wolf, is the result of a two-year field study of the relationship between timber wolves and Dall sheep, with notes on other animals. L. D. Mech's *The Wolf: The Ecology and Behavior of an Endangered Species* (Garden City: Natural History Press, 1970) is for the scientist and the general reader. The author's rich field experiences, combined with the established data, make this an interesting, well-documented volume. *Of Wolves and Men*, by B. H. Lopez (New York: Charles Scribner's Sons, 1978), concentrates on the wolf in the folklore and literature of different cultures. Most of the May 1967 issue of *American Zoologist* is devoted to the ecology and behavior of wolves. The issue includes “Numbers, Turnover, and Social Structure of the Isle Royale Wolf Population,” by P. A. Jordan, P. C. Shelton, and D. L. Allen (pp. 233–52). Points raised in this article are explored further in “Continued Studies of the Status, Socialization, and Relationships of Isle Royale Wolves, 1967–70,” by M. L. Wolfe and D. L. Allen (*Journal of Mammalogy*, vol. 54, no. 3, 1973, pp. 611–35). R. J. Rutter and D. H. Pimlott's *The World of the Wolf* (New York: J. B. Lippincott Co., 1968), is a profusely illus-

## ditional Reading

trated introduction for children that includes the authors' personal observations. Two *Natural History* articles are "The Social Organization of Wolves," by J. H. Woolpy (May 1968, pp. 46–55), and "Why Some Deer Are Safe From Wolves," by L. D. Mech (January 1979, pp. 70–77). Write to the North American Wolf Society, P.O. Box 118, Eatonville, WA 98328, for a list of books, pamphlets, and government publications on wolves. This society publishes a quarterly journal and sells reprints of its articles.

**Climate** (p. 64)

For a more complete treatment of climatic change and paleoclimatology, see *Climates of Hunger: Mankind and the World's Changing Weather*, by R. Bryson and T. Murray (Madison: University of Wisconsin Press, 1979). E. Le Roy Ladurie's *Times of Feast, Times of Famine: A History of Climate Since the Year 1000*, translated by Barbara Bray (Garden City: Doubleday and Co., 1971), is an outgrowth of the author's research into the history of agriculture in Europe. *Climates of the Past: An Introduction to Paleoclimatology*, by M. Schwartzbach (New York: AMS Press, 1977), first published in 1963, is a general text, while *Descriptive Paleoclimatology*, edited by A.E.M. Naun (New York: John Wiley and Sons, 1961), is a more technical symposium. R. Carpenter discusses the impact of climatic change in *Discontinuity in Greek Civilization* (New York: W. W. Norton and Co., 1968). "Climate of the Central North American Grasslands," by J. R. Borchert (*Annals of the Association of American Geographers*, vol. 40, 1950, pp. 1–39), and "A Pre-Columbian Urban Center on the Mississippi," by M. L. Fowler (*Scientific American*, August 1975, pp. 92–102), are specialized articles.

*Katharine D'Agosta*

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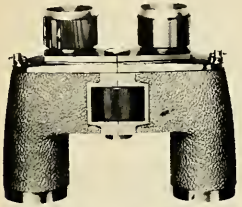

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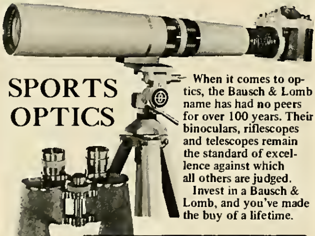

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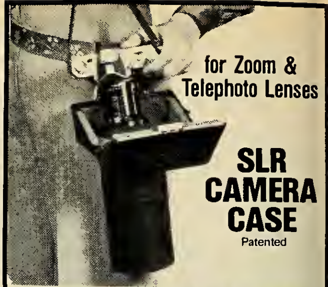

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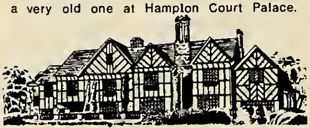

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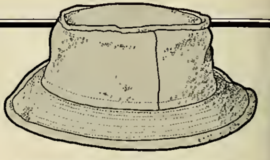

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All photographs taken by Adelaide de Menil at Allen's Neck Clambake

# An Original Old-fashioned Yankee Clambake

*Tradition is alive and well in New England!*

**by Raymond Sokolov**

The most exclusive and elaborate event in the American culinary calendar takes place on a tree-lined plot of land near Dartmouth, Massachusetts, in August. Last year, Wilfred Morrison, the proprietor of Davoll's General Store in the nearby hamlet of Russells Mills, was the *chef de cuisine*. He presided over a brigade of more than one hundred *sous-chefs*, who had worked for days to get this multicourse extravaganza onto the plates of five hundred lucky guests, who had signed up in time to secure a seat at one of the long wooden picnic tables across the path from Morrison's alfresco kitchen. Two thousand eager gourmets were turned away.

Unlike most modern chefs, Morrison did not cook with gas on a massive professional range. Indeed, he had no range at all, but insisted on a traditional, one might even say aboriginal, oven constructed, *à l'improviste*, from rocks, wood, and canvas. No wire whisks, copper pans, or Cuisinarts were allowed on the premises, only the canonical utensils sanctified by ninety previous years' experience: long-handled steel shovels.

The Allen's Neck Clambake began as an outing for the Sunday school of the local Quaker meeting in 1888. Originally held on Horseneck Beach, it moved slightly inland after 1903, but it is still within smelling distance of the Massachusetts shore in the state's biggest surviving agricultural region, just

to the east of the Rhode Island line. Getting lost in the maze of winding country roads running around farms is inevitable the first time you visit the area. The rational highway system of modern America is only minutes away, but just far enough to preserve the area from creeping exurbia. And because of this isolation from the socioeconomic mainstream, the life of the region has been spared the worst, most deracinating shocks that have shaken much of the rest of New England. A community of dirt farmers and gentry with a conservative outlook is holding its own on the east branch of the Westport River. And the Allen's Neck Clambake is its high-water mark, a historic ritual that transcends its official purpose of raising funds for the Friends Meeting House.

When working folk and local Brahmins sit down side by side over paper plates filled with steaming clams and ears of corn redolent of rockweed, there is a spirit of oldtime, small-town democracy in the salt air, the same spirit that once animated town meetings in New England. Perhaps the mood is mainly symbolic, but at least the symbolism is pure and unadulterated by slickness, shortcuts, and Chamber of Commerce hoopla. The genius of this clambake is its unremitting, stiff-necked fidelity to a method of cooking and a menu that have not changed since the dawn of the Republic, when settlers learned to cook the corn and shellfish of their newfound land in ad hoc ovens the Indians had invented and perfected on the rocks and sand of that same coast.

The New England clambake has as much claim to the title of our national feast as Thanksgiving, except that Thanksgiving flourishes everywhere, while the clambake has mostly fallen into neglect and been distorted by modern notions. Even some of the clambake's most devoted adherents will succumb to the proddings of their sensual natures and embellish the bake with lobsters. Others, hoping to simplify the cumbersome, labor-intensive

rocess of watching and controlling he bake, conduct this chthonic cookry in a metal prison that started out s a washtub.

At Allen's Neck, the bakemaster as always held the line against lobster ancification. And teams of willing veed-rakers and rock-pilers have been urning out early and late for more han fourscore years. This combinaion of abundant manpower and a menu codified right down to the tripe see recipe) has preserved the original Yankee clambake in as rugged and ristine form as modern conditions will allow.

Today, it is true, the menfolk no longer sail a catboat into Buzzard's

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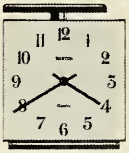

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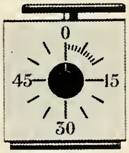

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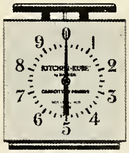

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Bay for fresh fish. And clams are no longer dug locally. The fish (mackerel) comes already filleted from a wholesaler. Clams arrive from Maine, where they were dug commercially in Machias Bay. But the corn is picked in a local field the morning of the bake. And the process of the clambake itself is militantly unchanged.

On the eve of the bake last summer, some twenty volunteers, men and boys, waded into the east branch of the Westport, collecting rockweed under the watchful eye of Karl Erickson, a retired schoolteacher with twenty years' experience on the clambake committee. He picked up a handful of rockweed and pointed out the blisters all over it. "They're full of water," he explained. "When they're heated, that water makes our bake into a natural steam pressure cooker."

It was almost nightfall before the pickup truck on the riverbank was full of rockweed. Meanwhile, other volunteers had been gathering the rocks and the hardwood for the fire.

By 7:15 A.M. the day of the bake, all of the raw materials had been assembled at the site, except for the corn, still to be picked, and the clams, which would soon be laboriously sorted and washed in a boat filled with seawater on the sand at Horseneck Beach.

At the site, a team of teen-agers started building the huge fire. They began with a concrete apron covered with a platform of long green oak stringers, on which were laid alternating levels of cut hardwood and stones. One girl, hefting a granite rock as big as her head and passing it on down the line, said, "This is great. All these years we've been coming here and we never knew this was how it was done."

Eventually, she and her friends had built an oblong rock and wood structure that stood five feet high and measured about twelve feet long and four feet across. There was kindling on top and gasoline-soaked paper underneath. At 8:45 the fire was lit and roared away brightly. "Utopia," said Karl Erickson, "is when it burns so there's not a stick of wood left, just charcoal and stones." By 9:00, all the food was cut and trimmed, bagged and racked, ready to cook. J.T. Smith, 91 years old and a former bakemaster, looked on approvingly.

By 10:45, the fire had burned down to a pyramid of rocks. It was time for the pullers. With their long-handled shovels, they dragged the hot rocks off the cement apron so that the charcoal and ash could be cleaned away. No wood smoke should defile the bake.

Speed was crucial so that the rocks wouldn't cool any more than absolutely necessary. As soon as the cement was clean, back went the rocks. On top of them came the rockweed. The food was set out in layers on the rockweed: the racks of clams first, the delicate corn last. Then the whole sizzling pile was covered with a soaked sheet and six layers of canvas; the edges of these cloths, where they met the ground, were caulked with rockweed. Clouds of vapor rose when the sheet went on, but the extra canvas shrouding and the rockweed sealed in the steam. The last edge was tamped down at 11:45. Twenty minutes later,

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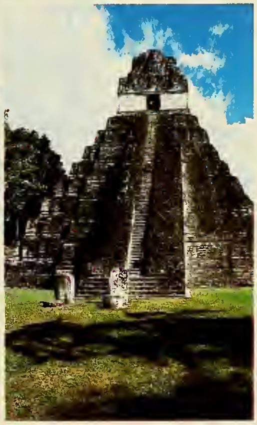

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steam pressure made the canvas billow up taut as a sail in a good wind.

Now Ralph Macomber could rest while the clambake baked. This burly sawyer had supervised the trickiest part of the ritual, the breaking down of the fire and the piling up of the hot stones. And at one o'clock, as 500 eager guests gathered round, it was his job to reach down, pull up a corner of the canvas, and gingerly extract a finger-burning clam. Out of the shell it came, and into his mouth it went. Macomber pronounced it done.

Off came the six canvases and the sheet. Ravenous diners took their places at the tables, and efficient teams of servers moved about, distributing the mountain of food. On my paper plate was a feast without equal. The clams, especially, were remarkable—fresh and tender and permeated with the aroma of rockweed and ocean. I was happy. Wilfred Morrison was happy. Karl Erickson was happy. Ralph Macomber was happy. We stuffed ourselves with an abandon that itself is part of the clambake tradition. The late Skipper Howland, a chronicler of New England life and the grandfather of my host at Allen's Neck, wrote the classic description:

> The first bowl of clams disappears with surprising speed. Another relay appears, reinforced with fish, corn, and potatoes from the bake, and slices of brown bread and helpings of onions from the center of the table. But from this point on how can I attempt to set down in words, which after all are poor things, the disposal of all these gifts of God, which have been for the most part cooked in the good earth, seasoned by the salts thereof, uncontaminated by the impurities of civilization, fresh as the dawn; in such abundance that no one has to bolt his first helping to ensure a second, third, or even a fourth—except to say that, when every soul here gathered has filled himself or herself to comfortable capacity, and those who smoke have ignited the butt ends of Manila cheroots that have come tied in bunches with buttercup-yellow ribbands in leaden chests from the Far Eastern Isles, the day sinks softly and peacefully down toward its end in a pale blue smoky haze of contentment; a contentment that can come only from the know-how of making the most of Nature's gifts and the satisfaction arising from such knowledge, which has been acquired, not from endowed institutions of learning, but from attendance at that greatest of all universities, the outdoor world.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

**Clambake to Feed 500 Paying Guests**
**Plus 125 Workers**

(From the *Allen's Neck Friends Cook Book*)

| | |
|---|---|
| | A safe, smooth, convenient site |
| 1 | cord of dry hardwood in 4-foot lengths |
| 1 | truckload of rockweed |
| 1½ | tons of stones about the size of a cantaloupe melon |

All clambakes are not alike; they vary in menu. Allen's Neck always has the same menu:

| | |
|---|---|
| 22 | bushels clams |
| 200 | pounds sausage |
| 75 | pounds fish fillets |
| 150 | pounds tripe |
| 75 | dozen sweet corn |
| 3 | bushels sweet potatoes |
| 30 | pans of dressing |
| 100 | pounds onions |
| 20 | large watermelons |
| 85 | homemade pies |
| 50 | pounds butter |
| | Coffee |
| | Milk |

*Special Requirements*

A group of enthusiastic workers, willing to work from Monday through Thursday; without these people no clambake of this size would succeed.

The clams must be culled and washed in fresh seawater, in a boat at Horseneck Beach.

The sweet corn must be fresh and sweet—harvested the day of the clambake. The rockweed must be fresh and kept moist.

After all the food from the bake has been consumed, it is hard to imagine how 20 large watermelons and 85 pies can disappear, but they do! No person should ever leave an Allen's Neck Clambake unless he or she is "full to the gills."

Now the last, and most important, ingredient of all is to ask our dear Lord for good weather.

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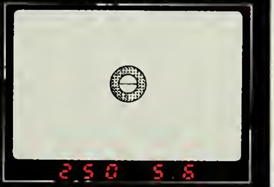

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# NATURAL HISTORY

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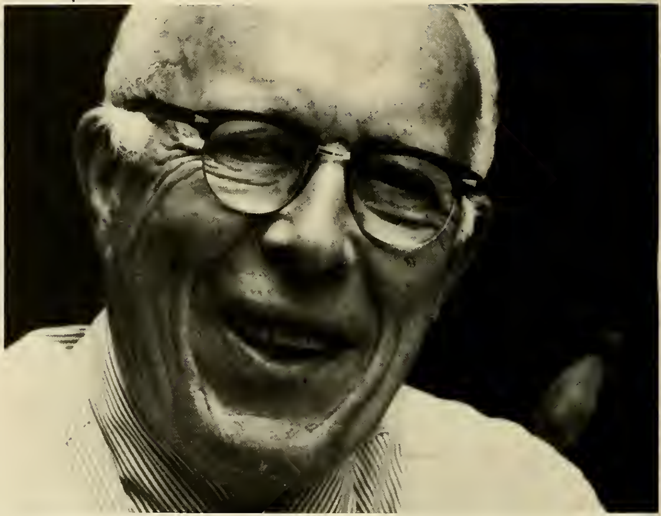
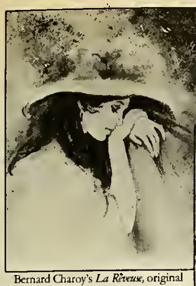
**René Dubos,** a microbiologist whose experimental work led to the discovery of important antibiotics, is equally well known as a successful popular author. Among the fifteen or so books he has written are *So Human an Animal*, for which he received a Pulitzer prize in 1969, and his most recent, *The Wooing of Earth.* Born in a small village in France in 1901, Dubos is a naturalized American citizen. He joined the staff of the Rockefeller Institute (now Rockefeller University) more than fifty years ago. Dubos has received numerous honorary degrees and other awards. He has never lost the constructive approach to problems he expressed in his foreword to *So Human an Animal:* "Man makes himself through enlightened choices that enhance his humanness."



**Niles Eldredge** began his study of the trilobite fossils he writes about in this issue partly by chance. An American missionary who had come to the American Museum of Natural History to have a fossil identified turned out to be a source of thousands of Bolivian fossils. Eldredge, who is investigating the role that species play in macroevolution, describes the essence of his research as trying to reconcile what he was taught with what he "sees in the rocks." He has found that natural selection cannot explain what he saw in the trilobite fossils and suggests some alternatives in his article. Eldredge is a curator in the Department of Invertebrates at the Museum.



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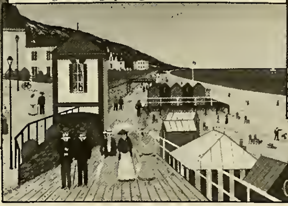

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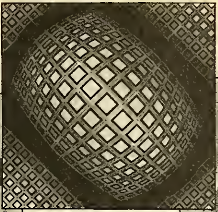

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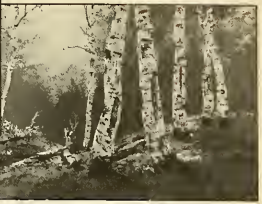

Huertas Aguiar's *Birch Trees*, original lithograph. Signed limited edition of 195

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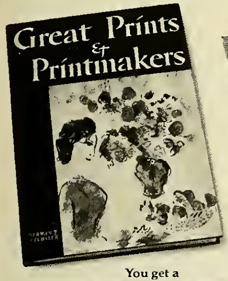

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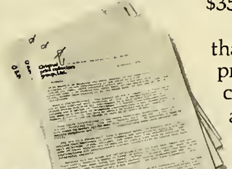

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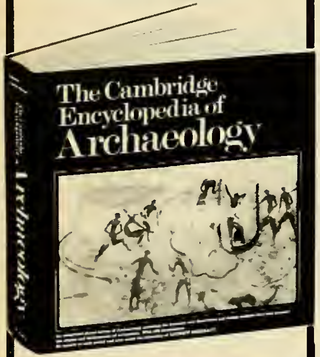

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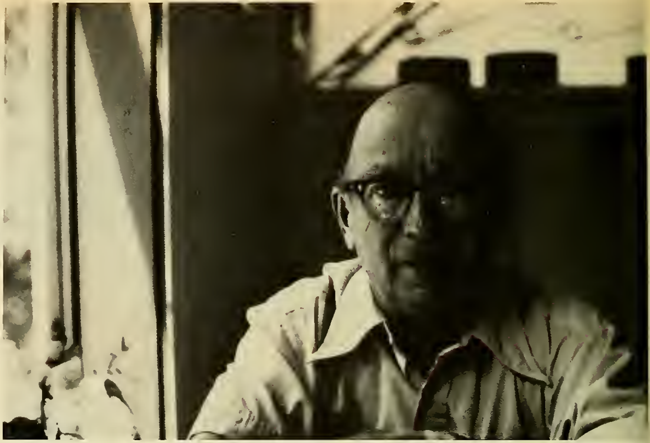
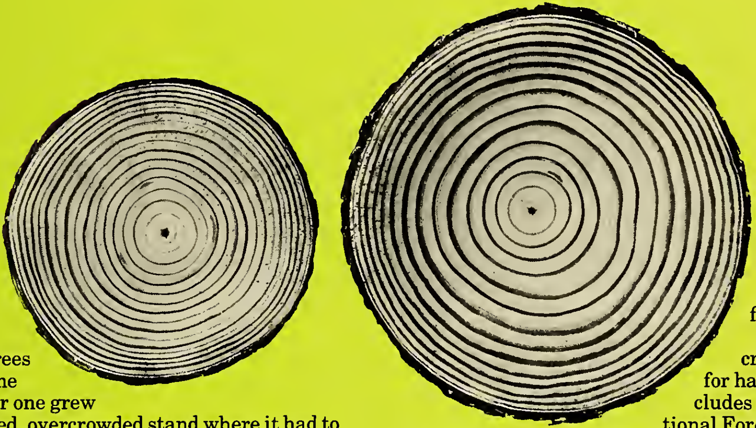


Salmon have been central to the interests of **Anthony Netboy** since 1952. That was the year he joined the Bonneville Power Administration in Portland, Oregon, to report on the problems of hydroelectric development of the Columbia River. He went on to write *Salmon of the Pacific Northwest: Fish v. Dams*, published in 1958. Other books followed as he became caught up in the story of the salmon's fight for survival. He has studied the fish in Europe, Asia, and Alaska, and claims to have visited every country that has, or has had, salmon, except Russia, Korea, and China. A native of Poland, Netboy was a professor of English with the Oregon State System of Higher Education until his retirement in 1971.

Born in Kabul, **Ashraf Ghani** understands the personal dilemmas that current developments have forced upon the educated segment of Afghanistan's population. Basing his account on the lives of people he knows, he has sought to dramatize for *Natural History* readers the perspective of a typical rural schoolteacher. Ghani did fieldwork in Afghanistan from 1973 to 1977, earning a master's degree in political science from the American University of Beirut. Since then he has been working toward a Ph.D. in anthropology from Columbia University; he received his Master of Philosophy this spring. Ghani's present research concerns political developments in Afghanistan from 1747 to 1978, the emergence of capitalist agriculture in Europe and the Middle East, and general anthropological theory. Hunting, mountain climbing, and collecting old books are among his diversions.

A report on the great American forest.

# Look what happens when Mother Nature gets a little help.



These log slices dramatically show the value of modern, scientific forest management. Both (shown 36% of actual size) are from trees of about the same age. The smaller one grew in an unmanaged, overcrowded stand where it had to compete for sunlight and moisture. The other is from a grove that was thinned to give the best trees room to thrive.

This is just one of many ways forest management can help meet a predicted doubling of domestic demand for wood and paper products in the next 50 years.

The forest industry has learned how to help Mother Nature grow more trees, faster, by applying scientific forest management techniques: encouraging natural regrowth, planting superior seeds and seedlings, fertilizing, protecting against disease and insects, thinning, watching carefully until time to harvest — then starting the cycle again.

## Demand keeps rising.

Forest management like this is vital because every year Americans need more homes, more paper products, more packaging and containers, more fuelwood, more of the thousands of other essential products that only the forest can provide.

So far, the country's commercial forest has been able to keep up with demand. (*Commercial forest,* as defined by the U.S. Forest Service, is *all* forestland—whether owned by individuals, government or the industry—that is capable of, and potentially available for, growing repeated crops of trees for harvest. It includes land in National Forests but not in National Parks or Wilderness areas.)

But trees aren't grown equally fast by all commercial forest owners. Though industry has made striking advances on its lands, productivity is lower on privately owned lands and seriously lagging in National Forests.

## Productivity not up to potential.

Overall, the U.S. Forest Service estimates average productivity of all commercial forestland is only 61 percent of potential. And at the same time, actual acreage in commercial forests keeps shrinking, as land is withdrawn for homes, highways and other needs of an expanding population.

So we as a nation still have a long way to go if our wood and paper products are not to become scarce and expensive.

If you'd like to be better informed on how important it is to keep America's forests productive, write American Forest Institute, P.O. Box 873, Springfield, VA 22150 for a free booklet, "The Great American Forest."

The great American forest. Trees for tomorrow. And tomorrow. And all the tomorrows after that.

**Trees. America's renewable resource.**

# You and the Ecology Movement

**Prepared by**
**Luther P. Gerlach**
**Virginia Hine**
**Betty Radcliffe**

In June-July 1970 *Natural History* ran a questionnaire on the ecology movement, as it was then called; in December 1970, we reported to our readers on their responses.

Ten years later, with what is now called environmentalism a good decade old, we are running another questionnaire, based closely on the first, that we hope will tell us how the opinions and actions of our readers have changed. Perhaps it will even give us some clues as to how the ecology/environmental movement itself has changed in ten years.

Luther P. Gerlach, the anthropologist who was principally responsible for the first questionnaire, has revised his earlier work for this second look. And just as with the first questionnaire, we'll report back to you in a later issue on the response to this one. Ten years ago you told us what you thought. We'd like to know what you think now.

To answer the questionnaire, follow the instructions for each section. Mail your answers to:

Natural History,
77 West 77th Street,
New York, New York 10024

Please answer the first thirteen questions by putting in the answer box on the following page the number that best describes your attitude:

(1) Strongly agree
(2) Agree
(3) Uncertain
(4) Disagree
(5) Strongly disagree

1. I believe plants and animals exist primarily for people's use and enjoyment.
2. With advances in technology, I think people will always be able to draw the resources they need from the environment.
3. I think environmental degradation, social injustice, and economic inequality are part of the same basic problem in our society.
4. I am concerned that using nuclear sources for energy may seriously endanger human life on this planet.
5. I believe churches should be actively involved in the critical social and environmental issues of our day.
6. I think owners of private property should be free to use the plants and other natural resources on it pretty much as is now permitted by law and convention.
7. I believe the profit motive in our society (desire for individual economic gain) is outdated and must change.
8. I feel that our environmental problems probably cannot be solved by existing American political and economic institutions.
9. I think all American families, regardless of social or economic position, must limit the number of children to two or, at most, three.
10. I believe our ecological problems can be solved primarily by the application of technology.
11. I think that we are indeed running out of fossil-based fuels.
12. I believe that economic growth is nearly always good for any community.
13. I believe that I have personal responsibility in the fight against pollution.

Please answer questions 14 through 25 by putting in the answer box the number of the statement that best describes your opinion.

14. How do you see yourself in relation to the influential and powerful groups in your community?
   (1) I am part of them and have a voice in decision making.
   (2) I feel part of them although I do not make decisions.
   (3) I am part of them but dislike it.
   (4) I am outside of them, but have a voice in decision making.
   (5) I am outside of them but not opposed to them.
   (6) I am outside of them and dislike them.
   (7) I am outside of them and actively oppose them.

15. At what level can we best solve our major air-, water-, and land-pollution and degradation problems?
   (1) Increasingly manage these problems as parts of complex systems on state, federal, and international levels.
   (2) Increasingly rely on local governments to implement and enforce strong measures.
   (3) Increasingly rely on individuals to do the right thing.

16. What do you consider to be our main energy problem?
   (1) Lack of a coherent, effective national energy policy.
   (2) Shortage and/or high prices.
   (3) Social impacts of current development strategies.
   (4) Dependence upon external, especially OPEC, oil.
   (5) Decision-making process too centralized.
   (6) Ecological costs (impacts) of energy development.

17. Which of the following seems to you the most desirable approach to achievement of a better, more adaptive energy and environmental future?
   (1) Interconnecting our energy grids more tightly, for example with Canada and Mexico, in hemispheric energy systems.
   (2) Making a massive shift to fossil-based synthetic fuels, solar electric power from solar-power towers, photovoltaic arrays, or satellites.
   (3) Integrating conventional fossil-fuel technologies and renewable-energy alternatives in both centralized and decentralized, large and small systems.
   (4) Developing community level conservation methods and local energy resources.
   (5) Increasing individual self-reliance through the use of rooftop solar collectors, using wood for home heating, etc.

18. Which of the following methods do you feel will *most effectively* resolve current conflicts over energy development?
   (1) Shifting to small-scale energy technologies and decentralizing decision making about energy production and distribution.
   (2) Improving and expanding citizen participation in decision making about nuclear- and fossil-fuel development.
   (3) Improving communication to the public of scientific concepts and technological facts about nuclear and fossil-based fuels.
   (4) Seeking compromise through mediation or conciliation.

(5) Lowering our expectations to reduce consumption and to accept some environmental risk.

19. Which of the following do you consider to be our most critical environmental problem?
(1) Water pollution.
(2) Air pollution.
(3) Nuclear and other hazardous waste buildup and storage.
(4) Increased societal costs of pollution control.
(5) Inadequate or unenforced regulatory legislation.
(6) Loss of land to highways, development, urbanization, etc.

20. Please give your age group.
(1) 19 or younger
(2) 20–24
(3) 25–29
(4) 30–39
(5) 40–49
(6) 50–59
(7) 60–69
(8) 70 and older

21. What is your sex?
(1) Female
(2) Male

22. How many children do you have?
(1) None
(2) One
(3) Two
(4) Three
(5) Four or more

23. What is your level of education?
(1) Less than high school graduate.
(2) High school or equivalency diploma.
(3) Business or technical school.
(4) Some college.
(5) Two-year college degree.
(6) Four-year college degree or about to graduate.
(7) Some graduate professional school.
(8) Graduate (M.A., M.S., Ph.D.) or professional (J.D. or M.D.) degree.

24. What is your annual family income from all sources before taxes?
(1) Less than $5,000
(2) $5,000 to $7,499
(3) $7,500 to $9,999
(4) $10,000 to $14,999
(5) $15,000 to $19,999
(6) $20,000 to $24,999
(7) $25,000 to $34,999
(8) $35,000 to $49,999
(9) $50,000 to $99,999
(10) $100,000 and over

25. What is the nature of your present work?
(1) Manufacturing or distribution of products
(2) Construction, building trades, or real estate
(3) Retail, merchandising, or sales
(4) Engineering or technical
(5) Government
(6) Health services and sciences
(7) Education
(8) Social service
(9) Law
(10) Military
(11) Farming, fisheries, lumbering, mining
(12) Banking or finance
(13) Energy production or distribution
(14) Transportation
(15) Communications, arts, or entertainment
(16) Other (see answer box)

26. Please enter your Zip code.

The next six items (27–32) describe types of present, past, or ongoing activist movements. Think about how you feel about each type and place in the answer box the number that best describes the opinion you now hold of them:
(1) I support them and am active in them.
(2) I favor them generally but have not been active.
(3) I do not have a position or am uncertain how I feel.
(4) I agree with the goals but disapprove of some of the methods.
(5) I disapprove of these movements but am against repressive action against them.
(6) I disapprove and would like to see these movements suppressed.

27. Organizations or activist groups in the environmental movement.

---

# NATURAL HISTORY

77 West 77th Street, New York, N.Y. 10024

Here are my answers to your questionnaire:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
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38 39 40 41 42 43
☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

25. Other: ______________________________

34. Other or comments: ______________________________

______________________________

44. Organization and your role: ______________________________

______________________________

______________________________

I completed the 1970 questionnaire: ________ yes ________ no

28. Movements for equity and social justice (for example, movements of women, blacks, and American Indians; American agriculture movement; activism of seniors, handicapped, etc.)

29. Movements, including the antinuclear movement, protesting large-scale, centralized energy development: large coal-fired power plants, high-voltage transmission lines, related coal strip mining, and deep-water oil ports and pipelines.

30. Movements promoting small-scale, renewable, chiefly solar alternative-energy technologies.

31. Movements or campaigns to make corporations more accountable for actions believed to place at risk the health and welfare of workers and consumers here and in other countries.

32. The various movements focusing on change or self-actualization of the individual either through personal experience, such as meditation, or through interpersonal experiences, such as self-help or sensitivity groups.

Answer the following questions by placing the number(s) of your response(s) in the answer box(es) as directed.

33. Do you think that there is any connection between all or many of the various movements described above? (Choose one.)

(1) They are all aspects of one single wave of revolutionary change.
(2) They may be related but are still separate movements.
(3) There is some connection between some of them.
(4) I am uncertain what I think.
(5) There is no connection between them.

34. Please enter the numbers of any of the following actions that you have personally taken primarily because of your love of, or concern for, the environment (including concern about depleting, or the environmental effects of using, our fossil energy resources).

(1) Curtailed or greatly limited use of disposables.
(2) Made a practice of separating and recycling household garbage.
(3) Modified home to conserve energy or to use renewable energy.
(4) Moved to a more energy-efficient or solar home, to higher density housing, or closer to work.
(5) Gave up or decided to forego purchase of such items as home air conditioner or recreation vehicle.
(6) Have car pooled or used public transport as much as possible.
(7) Bought smaller and/or more gas efficient automobiles.
(8) Centered more recreational activities on hiking, biking, and the like, and less on the use of motors.
(9) Canoed or backpacked in wilderness areas.
(10) Have been seeking self-sufficient living in the country.
(11) Other and/or comment (See answer box).

35. Write in the spaces provided the numbers of any of these methods of influencing decision makers that you approve of.

(1) Writing letters to government officials.
(2) Speaking at public hearings.
(3) Bringing suit against corporations, government agencies, or individuals guilty of environmental negligence.
(4) Boycotting companies that don't seem environmentally or socially responsible.
(5) Rallies, marches, demonstrations.
(6) Nonviolent direct action, such as sitting in front of bulldozers.
(7) Citizen takeovers of offices of government agencies or industries to enforce demands.
(8) Destructive or violent action if other means fail.

If you are active in the ecology movement or in activist groups or movements that you feel have a strong environmental-concern focus, please complete the questionnaire, placing in the boxes for each question the numbers of as many responses as apply.

36. Which of the methods of influencing decision makers listed in the responses for item 35 have you engaged in?

37. In which of the following ways have you personally sought to influence people to become active in the environmental movement or to interest them in environmental problems?

(1) Personally calling or speaking to individuals.
(2) Giving or helping sponsor talks or programs, live or on radio or television.
(3) Writing or helping to prepare articles, letters to editors, handout materials, or flyers.

38. If your participation in the mov
ment has involved any risks, write i
the spaces provided the numbers
any of the following you have exp
rienced.

(1) Expenditure of great time
money.
(2) Loss of friends.
(3) Threatening mail or phon
calls.
(4) Pressure from employer.
(5) Serious family rift.
(6) Loss of job.
(7) Destruction of personal pro
erty.
(8) Arrest or conviction.
(9) Bodily harm.

Now, for the final questions, ent
in the answer box the number of th
one best response.

39. How many organizations co
cerned with environmental problem
do you belong to?

(1) None (4) Three
(2) One (5) Four or more
(3) Two

40. How often do you usually tal
to other people involved in these o
ganizations (telephone conversation
formal meetings, organizational mee
ings, etc.)?

(1) Never
(2) Few times a year
(3) Once a month
(4) Once a week
(5) Twice a week
(6) Three or four times a week
(7) Daily

41. Of the five people you feel close
to, how many are also involved in the
organizations?

(1) All five (4) Two
(2) Four (5) One
(3) Three (6) None

42. Has your involvement with thes
organizations changed your idea
about yourself and made you act di
ferently?

(1) No
(2) Yes, I have changed in som
ways.
(3) Yes, I have been radicall
changed.
(4) Undecided

43. How would you rate the approac
of the group in which you are mo
active?

(1) Conservative (3) Activist
(2) Moderate (4) Radical

44. Please list the organizations activ
in environmental problems that yo
support or are active in and indicat
the type of position you have hel
in them.

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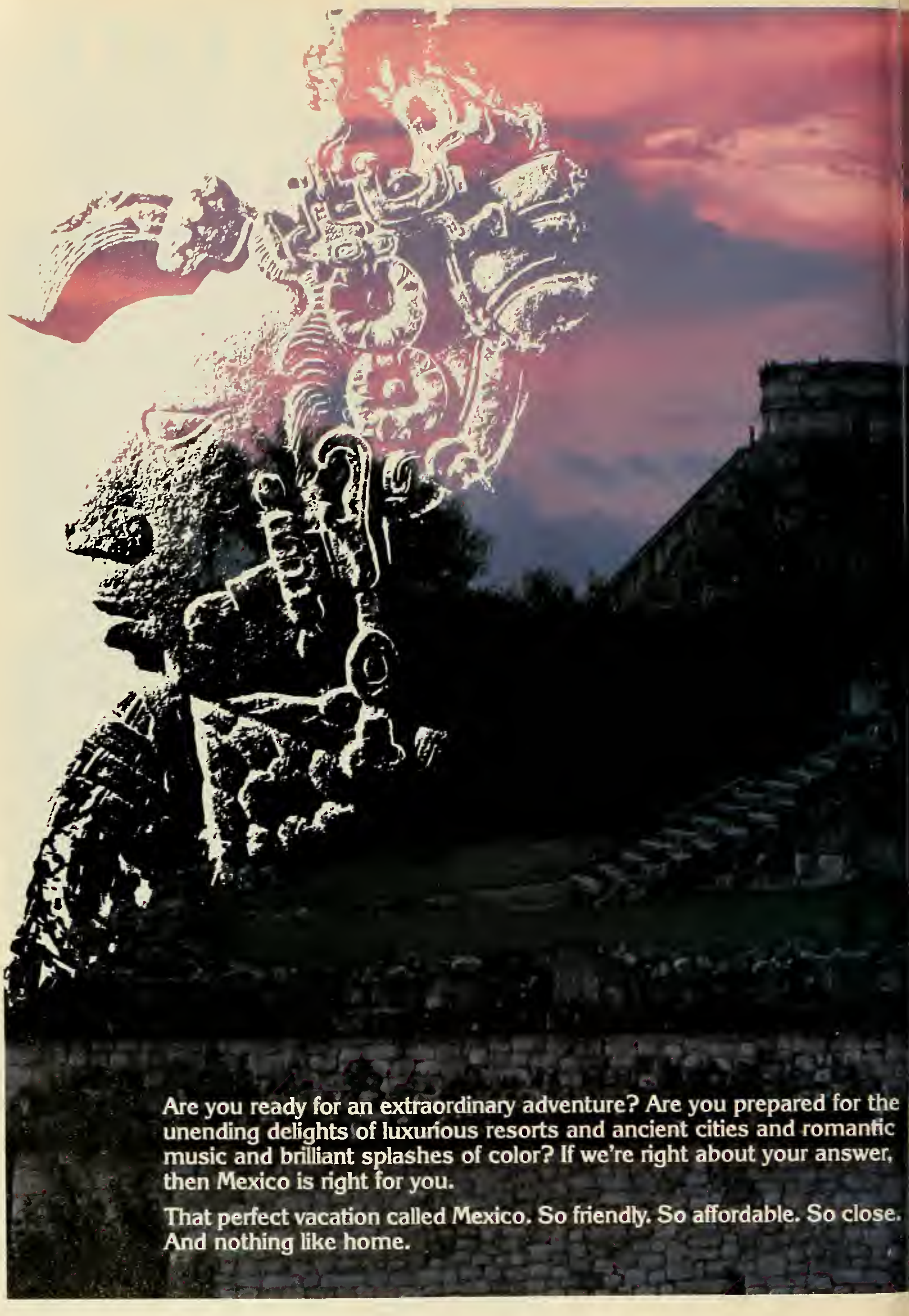

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## Building on Shifting Sands

From Maine to Texas, islands close to the mainland provide a coastal environment rich in estuaries, marshlands, and vacation homes. In June 1970, in "Barrier Beaches of Eastern America," Christopher Schuberth wrote about the natural processes that build up, change, and shape barrier islands such as Miami Beach, Fire Island, and Atlantic City. Waves pound the beach, storms toss the sand around, and the littoral current of water along an island shore slowly moves, if not mountains, at least beaches. On Fire Island, near New York City, the littoral current moves 600,000 cubic yards of sand westward each year.

As Schuberth pointed out, building on a barrier island is risky. The natural rearrangement due to currents and storms may not be kind to real estate or human life. Nor does development on the beaches secure them. If anything, building on barrier islands just makes things worse, particularly when residents try to halt the shifting sands.

There are federal programs to protect barrier islands, but development has been proceeding apace in recent years, and one reason, it turns out, is that the federal government, largely inadvertently, has encouraged that development. It sounds contradictory, but through unconnected programs not specifically related to barrier islands, "over three fiscal years, the permitting, granting, and licensing agencies committed nearly one-half billion dollars to barrier island development projects."

That quotation is from a Draft Environmental Statement prepared by the Heritage Conservation and Recreation Service in concert with several other federal agencies. The largest chunk of these funds came, ironically, from the Environmental Protection Agency in the form of waste-water treatment. The Army Corps of Engineers invested heavily in beach restoration and protection, which indirectly supported development. Home and business mortgage insurance programs supported investments.

It may turn out that not only the environment will suffer. The recent growth of the barrier islands' populations has occurred during a long period when storm activity has been unusually low. "Nearly 80 percent of the people now living in island cities and communities have never experienced a hurricane," according to the report. And on many islands the means of escape from storms is not adequate. "Even if they heed and take seriously a hurricane warning," says the report of the island residents, "it is doubtful that more than a relatively minor percentage could escape before the storm hits."

## Albinisms

As Carl Witkop reported in "Albinism," October 1975, abnormal pigmentation, in one form or another, affects all animals—and there are many forms. In mice, at least 147 genes at 62 loci are involved in controlling coat color.

In humans there are now thirteen known forms of albinism (and a variety of other pigment disorders that come under the name of albinoidism). Witkop has had a hand in discovering two of these thirteen since his *Natural History* article.

One form is called Autosomal Recessively Inherited Ocular Albinism, and its recognition is important in genetic counseling. A more recent discovery called simply Brown Albinism was made by a research group in Nigeria, where many albinos suffer terribly from skin cancer because they lack the protection that pigment affords from the sun's rays. Witkop and his colleagues found the new form of albinism in the members of the Ibo tribe they were studying. These albinos had a light brown skin and did not suffer increased rates of skin cancer.

## Getting Along with Seals

When Gerald Kooyman wrote h 1976 article, "Deep Divers of the An arctic," he was spending a lot of h time with seals. He and his coworke would find the 1,000-pound Wedde seals on the ice, attach recorders them, and haul them by sled to hut over an isolated hole in the ic which usually tempted the seals dive immediately. "Occasionally wrote Kooyman, "a seal did not ent the water for several hours and the we were obliged to share our hut wi the animals for the evening or tl night—which reminded us of the jol about where does a 500-pound goril sleep."

Kooyman is still spending time wi seals, but he has his hut to himse now. He has turned to more ecolog cally, less physiologically oriente studies of how free-ranging seals div As expected, seals dive for shorter p riods of time when they are free ran ing. In a forced dive, they spend longer time under the ice because the are looking for a new hole to surfac through, not wanting to return to th "laboratory." Kooyman has yet to an lyze his data to produce any clea conclusions, but he did say the dept and length of the dives were high variable.

Although he has solved the hu problem, his work is still not the sam as dealing with white mice. Researc ers must approach a seal, put a ba over its head, and attach a record to its skin with what are known a hog rings, which pierce the skin. Koo man says the seals have tough an insensitive skin, and attaching the r corders causes little pain. But the sea tend not to like the whole process ve much. Which brings up the questic of how do you handle an unhapp 1,000-pound seal. Very carefully?

*James Gorma*

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# Nutritional Ambiguities

*A diet suitable for one individual may be dangerously deficient for another*

**by René Dubos**

Many people of the Western world, especially in the United States, are intensely worried about their nutritional state and the quality of their food. This worry, however, is not caused by malnutrition but by constantly reading and hearing about the dangers of bad diets and of food contaminated with additives and other chemicals. Any departure from what Westerners assume to be an ideal natural diet is publicized by the mass media, thus contributing to the prevalent social neuroses about the general state of the world.

The reality is that most people in the developed and even semideveloped parts of the world now have diets that are better balanced and freer of toxic contaminants than at almost any time in the past, except perhaps during the Old Stone Age. Food shortages occurred frequently, even in Europe, as recently as a century ago, vitamin and other deficiencies affected many people at the end of the winter, microbial spoilage of food was difficult to avoid, and contamination with toxic substances often caused acute disease and death. It took Upton Sinclair's hair-raising stories in *The Jungle*, published in 1906, to make Congress create the Food and Drug Administration, which, among other functions, oversees the safety and quality of foodstuffs.

I do not claim that our food and our nutritional state are now ideal, but I believe that their most serious shortcomings do not stem from a deterioration of our dietary regimen. If some, and perhaps many, of us are in a state of *mal*nutrition, it is because our dietary regimen is ill-adapted to modern conditions. It would be surprising if the nutritional regimens designed for the old ways of life were the right ones for the conditions prevailing in today's wheel-borne, well-heated, air-conditioned societies. We know a great deal about the characteristics of the various kinds of food but very little about what would be the ideal food intake for a particular person in a particular physiological, behavioral, or occupational situation.

Until recent times, nutritional science has dealt chiefly with such general problems as the chemical identification and synthesis of essential growth factors; the determination of the average requirements for each one of these factors, according to age, sex, and state of health; the metabolic role and fate of each one of the foodstuffs in the body. Under normal conditions, this broad theoretical approach was based on the belief that, within a given age group and sex, all human beings have essentially the same nutritional requirements. Initially, for example, the requirements for young male adults were determined by tests on healthy, vigorous American students at an Ivy League college. But many recent studies have revealed that every person has a nutritional-metabolic pattern that is characteristic, indeed as unique as fingerprints. For this reason, a diet that is suitable for one person may be marginal, deficient, and even dangerous for another.

Individual differences in nutritional requirements can be considerable. A recent study of nineteen healthy men found an almost fivefold difference in their daily requirements for calciu (from 220 to 1,018 mg) and two- seven-fold differences in their nee for the various essential amino aci that maintain nitrogen balance. The differences are certainly due in pa to genetic constitution, but exper ments in animals and observations i human beings leave no doubt that th nutritional needs of an individual ca undergo profound changes as a resu of adaptation to a shortage or abu dance of certain nutrients.

Some twenty years ago, a study wa made in India of a large group o beggars who had long been on a die deficient in calories, iron, calcium phosphorus, vitamins A, B, C, an D, and proteins of animal origin. T their great surprise, the investigator found that only 4 percent of thes beggars showed obvious signs of nutritional deficiency and that radiological examinations showed most o them to have a normally calcified ske eton. In the women of this group, lo nutritional intakes did not have markedly deleterious effect on eithe pregnancy or lactation; the growt rate of children was only slightly lowe than normal. While these beggar probably used items of food that escaped the attention of the investigators, nevertheless chronic food shor age appears to have created in ther some form of physiological adaptatio to low nutritional intake.

The ability to survive and even t function well with an inadequate die can probably be attributed in part t people in underprivileged countrie learning to eat certain items—incluc ing insects—considered unacceptabl in richer countries. Above and beyon

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these "social" adaptations, however, undernourished or malnourished people can also develop certain "biological" adaptations that supplement the food intake, such as the synthesis of vitamins and amino acids by intestinal microbes. Perhaps of greater importance are "metabolic" adaptations that enable the body to "gear down" its metabolic demands.

The existence of multiple forms of nutritional adaptation certainly accounts for the fact that persons differ widely in their nutritional requirements, the result not only of genetic differences but also, and even more, of different cultural habits, ways of life, and behavioral patterns. These differences make a mockery of attempts to define precisely an optimum diet for the hypothetical average person.

Many people believe that they can function well only when provided with three square meals a day, and certain students of nutrition believe that this formula constitutes the surest way to a good nutritional state. But, in fact, few are the societies in which the practice of three square meals a day is considered essential for health.

In the economically humble French environment from which I emerged, the substantial meal was eaten at noon, supper was a desultory affair, and as to breakfast, it consisted of bread with a cup of cocoa for children and coffee for adults. Never did a glass of orange juice or tomato juice reach my lips until I had settled in the United States. Yet here I am to tell the tale at the age of seventy-nine. My sister and brother, who are both in their late seventies and living in Paris, are still doing well on the same regimen, as are my French nephews and nieces. There are tribes in which people nibble constantly and others whose members partake of only one meal a day. At Harvard University, I knew a famous medical educator who ate only at dinnertime, when he could make the meal an elaborate social occasion.

In East Africa, the Kikuyu people are healthy and can develop a good physique on a vegetarian diet. In contrast, the Masai people, who live in the same region, derive practically all their nourishment from milk and from the blood of their cattle, which they bleed daily. Yet the Masai do as well as the Kikuyu without much intake of the plant fiber that is so much on our minds today.

I could go on and on with examples illustrating that social groups and individual persons have successfully adapted themselves to very different dietary regimens. I find it more useful, however, to discuss at some length a more drastic phenomenon of nutritional adaptation, namely, adaptation to extremely low food intake throughout the life span.

During the 1940s, I participated in the research activities of the Institute of Nutrition for Central America and Panama, situated in Guatemala City. The average per capita food intake in the villages of Guatemala was then, and still is, extremely low and deficient in protein. Many children and young adults died of infection. But those who survived to adulthood, although of short stature and seemingly frail, were capable of far greater physical efforts than those expected of vigorous Europeans and North Americans—such as carrying heavy burdens on their backs over long distances up and down mountains. Physiological studies showed that they could maintain themselves in caloric and nitrogen balance on a diet that would have meant starvation for most Europeans and especially for North Americans. Furthermore, these skinny people, grossly undernourished according to our standards, commonly lived to a good old age.

Since Guatemalans raised in wealthier surroundings and fed a rich and abundant diet became as large as people of Europe and North America and exhibited the high nutritional requirements of these countries, we can assume that the anatomical and physiological characteristics of the adult village Guatemalans were not the consequence of genetic peculiarities but rather of adaptation to low food intake.

Before World War II, most adult Japanese men and women were of small size, and this is still true of Japanese persons more than forty years old. In contrast, the average size of Japanese teen-agers and young adults is now close to that of young Caucasians in the prosperous parts of the world. The phenomenal increase of body size in Japan cannot be due to genetic factors since it occurred within one generation. One reason may be the control of childhood disease; another is certainly the profound changes in the Japanese diet since the end of the war. Between 1950 and 1975, for example, the per capita average consumption increased *15-fold* (not 15 percent) in the case of milk, 7.5-fold in the case of meat and eggs, and 6-fold in the case of fat, while the per capita consumption of rice and potatoes decreased significantly.

Thus it seems certain that the prewar Japanese people had adapted biologically to a low intake of certain nutritional elements (probably protein and fat) by remaining small throughout life. This biologically adaptive state had such profound effects that adult and old Japanese people who grew up under such conditions do not significantly increase in size even when they adopt today's much richer and more abundant diet.

As already mentioned, by the beginning of the century American nutritionists had worked out Recommended Daily Allowances for the various essential nutrients, in particular, proteins; these values were derived from the requirements of vigorous young adults, chiefly college students. Almost unanimously, however, nutritionists of other countries have long considered the American Recommended Daily Allowances far too high. In the early 1970s, the commissions on nutrition of the World Health Organization and of the Food and Agricultural Organization scaled down the protein requirements of a healthy person by some 30 percent—thereby eliminating, by administrative decision, the international "protein gap" that had been postulated in earlier decades.

Recent American research has been interpreted to mean that the redefined protein standards are in reality too low because in one study a group of U.S. university students developed signs of deficiency two months after being fed the new recommended levels of protein. The explanation of this finding, however, is probably that some twenty years ago most American children were fed (and to a large extent most still are) diets much richer and more abundant than those given European children, let alone children of underdeveloped countries. The nutritional requirements of adults are probably largely determined by nutritional conditioning during the early years of life.

Average Americans, and now many Europeans, feel that they need a daily food intake containing more than 2,500 calories and 70 grams of protein, preferably meat protein. In contrast, whole populations of other ethnic groups seem well adapted to diets pro-

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viding approximately 1,500 calories and 40 grams of protein, or even less, and often with hardly any meat. This was the case in Japan before the war and is still the case for most Guatemalan villagers. Moreover, the immense majority of people in all ethnic groups could almost certainly adapt successfully to either one of these two extreme types of dietary regimen or to any in between. We need to learn much more about the effects of nutritional conditioning, especially during early childhood, because several of these effects might be essentially irreversible and could therefore affect the person during the whole life span.

The most obvious long-range effects have to do with health. Good evidence exists, for example, that babies pressed to take more food become habituated to an abundant diet and tend to become obese, with all the health risks associated with obesity during adulthood and old age. The postwar generation of richly fed Japanese, both men and women, now tend to have the same disease patterns that are prevalent in North America and Europe, where cardiovascular diseases and various forms of cancer have become the leading causes of death. In all prosperous societies, people are becoming increasingly concerned about the harmful components of their diets—cholesterol, saturated fatty acids, processed foods, contaminants such as pesticides, and various forms of additives. They would worry even more if they realized that almost any article of food—even the most natural food—is toxic if taken in excess. For example, potatoes contain solanin, a substance that would create toxic effects if ten times the usual amount were eaten at one sitting; cereal grains contain phytic acid, which interferes with the absorption of calcium and iron; and certain plants of the cabbage family produce goiter. Even vitamins can be a cause of disease as in the case of hypervitaminoses A and D.

While proving that many particular food items, artificial or natural, are dangerous if taken in large amounts is fairly easy, establishing the dangers of the typical rich American diet is much more difficult. A very recent study sponsored by the American Society for Clinical Nutrition examined a number of suspected relationships between diet and disease but found only three that could be statistically confirmed: between sucrose and dental caries; between alcohol and cirrhosis of the liver; between salt and hypertension. Convincing evidence could not be obtained that high intakes of cholesterol and fatty acids increased the chance of dying from cardiovascular disease.

Lack of statistical proof does not, of course, rule out that high blood levels of cholesterol and fatty acids can be involved in disease causation. The great differences of response among the persons examined make it difficult to establish statistically valid correlations. As mentioned earlier, these differences may have their origin not only in genetic constitution but also in behavioral patterns. One example will suffice to illustrate how a seemingly trivial aspect of behavior can influence the digestion of lipids and, consequently, their possible effects on disease. After a meal, ingested lipids travel in the bloodstream for a short time in the form of microscopic particles called chylomicra. These particles are rapidly digested under normal conditions, but they persist much longer in a person under stress even when the stress is as mild as having to give an anatomy lecture to medical students. If lipids do contribute to the formation of vascular lesions, adaptation to certain stresses may thus decrease their ability to cause cardiovascular disease.

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Nutritional science therefore involves much more than knowing the requirements for essential growth factors and the toxic effects of food additives. A time may come when a particular patient's need for a particular food will be evaluated not only by measuring growth rates but also by determining the food's effect on specialized functions, such as the ability to develop scar tissue; produce new cells in the liver, spleen, and bone marrow; and generate the proper kind of response to detoxify poisons or drugs. There is now some evidence that the nutritional state can affect even behavioral responses, as shown by the brain's production of at least two neurotransmitters: serotonin which depends on the tryptophane level in the bloodstream, and acetylcholine, which depends on the choline level. Neither tryptophane nor choline can be manufactured by the body and must be supplied in the diet.

We have an immense amount of detailed knowledge about foodstuffs but know very little about their effects on the body and even less about their effects on behavior and on the social aspects of life. Developing a large body size is obviously an advantage for certain activities but probably not for others. Voltaire was a midget compared with Washington but outlived him by seventeen years and was at least as influential on the course of history. The small prewar Japanese could not play basketball with Americans; nevertheless, they were excellent soldiers and proved immensely successful in the technological and economic world of the postwar period. The new generation of richly fed Japanese is much taller than the preceding one but we do not know that its members will live longer or be happier. A good, abundant nutritional regimen will keep us alive, make us grow to a certain size, and protect us from deficiency diseases, but beyond that, we really do not know much about its effects on our bodies, our society and the future of civilization.

To illustrate our ignorance, and also the possibility of adapting successfully to extremely different dietary regimens, I shall mention the nutritional habits of two famous physicians whom I knew well during my early years at the Rockefeller Institute for Medical Research. One was Henry William

Welch, the architect of medical and public health sciences in the United States. The other was Oswald T. Avery, who is famous for his studies on infectious diseases and for having first demonstrated that DNA is the carrier of hereditary characteristics. Welch and Avery were approximately the same height, had received similar college and medical educations, spent most of their lives in academic medicine, remained bachelors, smoked a great deal, took practically no physical exercise, and never tired of talking. But they differed competely in nutritional behavior.

Welch had a Gargantuan appetite, with a preference for rich, well-seasoned foods. He was inordinately fond of sweets and prone to end his meal with several helpings of ice cream—in a period when this meant real cream. He loved wine and hard liquor and seemed proud that his most violent form of exercise was taking off his shoes at night and putting them on in the morning. He early became obese, loved fun and the carnival aspects of life, and remained intellectually active to the end of his life. He died of cancer in his eighty-fifth year.

Avery ate sparingly. Two slices of toast, a few leaves of lettuce, and several cups of coffee seemed to be his ideal meal. We used to say that he could be in nutritional balance only by fixing atmospheric nitrogen. He never weighed more than ninety pounds during the thirty years I knew him, yet he was constantly active, either in laboratory work or participating in discussions. He suffered from mild hyperthyroidism, and his disease took a more active form during a period of disappointments in his research program. After surgery and a few months rest, he came back to the laboratory and resumed his activities. He died of cancer in his seventy-ninth year.

As far as I know, no nutritional studies have been carried out on either Welch or Avery. One can take it for granted that genetic differences between them played a role in their contrasting attitudes toward food intake and responses to it, but one can also assume that their nutritional habits and their metabolism were profoundly influenced by other aspects of their ways of life, and probably by their early experiences. It takes more than a knowledge of foodstuffs to create a science of human nutrition. □

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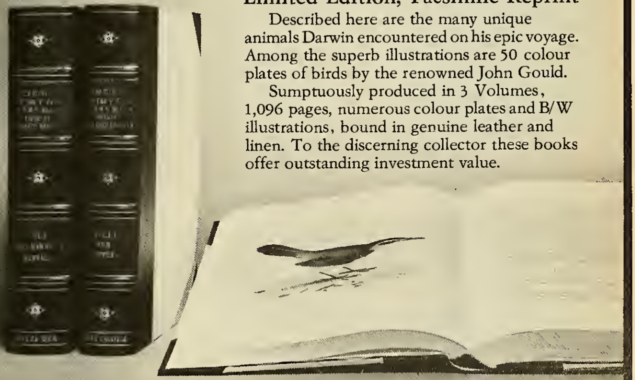

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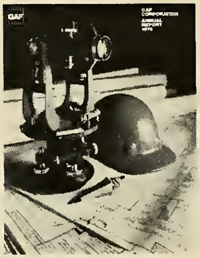

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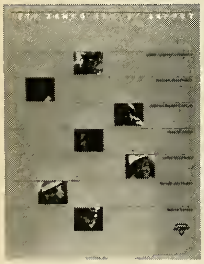

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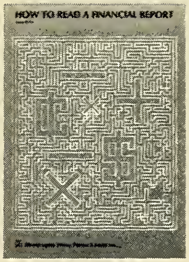

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# Hen's Teeth and Horse's Toes

*Rather than an embarrassment, "throwbacks" are evolutionary reminiscences with intriguing implications*

**by Stephen Jay Gould**

Vanity license plates are just the latest expression of an old conviction that distinctive conveyances reflect status or, at least, compel notice. We can build our modern machines to order, but nature has narrower limits. Horses of unusual size or color commanded great favor, but Julius Caesar ventured beyond the mere accentuation of normality in choosing his favorite mount. The historian Suetonius writes that Caesar

> used to ride a remarkable horse, which had feet that were almost human, the hoofs being cleft like toes. It was born in his own stables, and as the soothsayers declared that it showed its owner would be lord of the world, he reared it with great care, and was the first to mount it; it would allow no other rider.

Normal horses represent the limit of evolutionary trends for the reduction of toes. Ancestral *Hyracotherium* (popularly, but incorrectly, known as *Eohippus*) had four toes in front and three in back, while some earlier forebear undoubtedly possessed the original mammalian complement of five on each foot. Modern horses retain but a single toe, the third of an original five. They also develop vestiges of the old second and fourth toes as short splints of bone, mounted high and inconspicuously above the hoof.

Abnormal horses with extra digits have been admired and studied since Caesar's time. O.C. Marsh, a founder of vertebrate paleontology in America, took a special interest in these aberrant animals and published a long article on "Recent polydactyle horses" in the *American Journal of Science* for April 1892. Marsh had two major claims upon fame, one dubious—his acrimonious battles with E.D. Cope in collecting and describing vertebrate fossils from the American West—and one unambiguous—his success in deciphering the evolution of horses, the first adequate demonstration of descent provided by the fossil record of vertebrates, and an important support in Darwin's early battles.

Marsh was puzzled and fascinated by these aberrant horses with extra toes. In most cases, the additional toe is merely a duplicate copy of the functional third digit. But Marsh found that a fair number of two- and three-toed horses had harkened back to their ancestors by developing either or both of the side splints into functional (or nearly functional) hoofed toes. (A later, and particularly thorough, German monograph of 1918 concluded that about two-thirds of horses with extra toes had simply duplicated the functional third digit, while about one-third had resuscitated an ancestral feature by developing the vestigial splints of their second or fourth toe into complete, hoofed digits.)

These apparent reversions to previous evolutionary states are called atavisms, after the Latin *atavus*: literally, great-great-great-grandfather; more generally, simply ancestor. The biological literature is studded with examples of the genre, but they have generally been treated anecdotally as mere curiosities bearing no important evolutionary message. If anything, they are surrounded with the odor of slight embarrassment, as if the progressive process of evolution did not care to be reminded so palpably of its previous imperfections. The synonyms of European colleagues express this feeling directly—"throwback" in England, *pas-en-arrière* ("backward step") in France, and *Rückschlag* ("setback") in Germany. When granted any general significance, atavisms have been treated as marks of constraint, as indications that an organism's past lurks just below its present surface and can hold back its future advance.

I would suggest an opposite view—that atavisms teach an important lesson about potential results of small genetic changes, and that they suggest an unconventional approach to the problem of major transitions in evolution. In the traditional view, major transitions are a summation of the small changes that adapt populations ever more finely to their local environments. Several evolutionists, myself included, have become dissatisfied with this vision of smooth extrapolation. Must one group always evolve from another through an insensibly graded series of intermediate forms? Must evolution proceed gene by gene, each tiny change producing a correspondingly small alteration of external appearance? The fossil record almost never records smooth transitions, and it is often difficult even to imagine a function for all hypothetical intermediates between ancestors and their highly modified descendants.

One promising solution to this dilemma recognizes that certain kinds of small genetic changes may have

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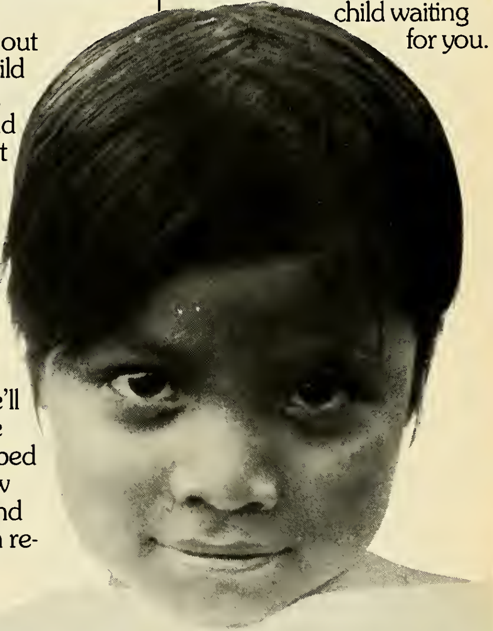

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major, discontinuous effects upon morphology. We can make no one-to-one translation between extent of genetic change and degree of alteration in external form. Genes are not attached to independent bits of the body, each responsible for building one small item. Genetic systems are arranged hierarchically; controllers and master switches often activate large blocks of genes. Small changes in the timing of action for these controllers often translate into major and discontinuous alterations of external form. Most dramatic are the so-called homeotic mutants causing spatial shifts in the expression of blocks of genes. In *bithorax* mutants of the fruit fly *Drosophila*, for example, small changes in any of five closely linked genes cause posterior parts of the body to appear in more forward positions or anterior parts to develop farther back. Changes are often discontinuous, not graded. Halters, organs used for maintaining balance during flight, may be replaced by true wings. In an even more striking and peculiar mutation, called *aristapedia*, the tarsus of a leg, with all its structures, appears on the head where an antenna should form.

The current challenge to traditional gradualistic accounts of evolutionary transitions will take root only if genetic systems contain extensive, hidden capacities for expressing small changes as large effects. Atavisms provide the most striking demonstration of this principle that I know. If genetic systems were beanbags of independent items, each responsible for building a single part of the body, then evolutionary change could only occur piece by piece. But genetic systems are integrated products of an organism's history, and they retain extensive, latent capacities that can often be released by small changes. Horses have never lost the genetic information for producing side toes even though their ancestors settled on a single toe several million years ago. What else might their genetic system maintain, normally unexpressed, but able to serve, if activated, as a possible focus for major and rapid evolutionary change? Atavisms reflect the enormous, latent capacity of genetic systems, not primarily the constraints and limitations imposed by an organism's past.

My columns often suffer from runaway introductions, fueled by overenthusiasm for a latent generality inspired by a particular story. The preceding paragraphs were suggested by a recent report of something that has no right to exist if one of our most venerable similes expresses literal truth—hen's teeth. In *Science* for February 29, 1980 (enough of a rarity in itself), E.J. Kollar and C. Fisher reported an ingenious technique for coaxing chickens to reveal some surprising genetic flexibility retained from a distant past.

They took epithelial (outer) tissue from the first and second gill arches of a five-day-old chick embryo and combined it with mesenchyme (inner embryonic tissue) of sixteen- to eighteen-day-old mouse embryos from the region where first molar teeth form. A fascinating evolutionary tale lies hidden in this simple statement as well. Jaws evolved from bones supporting the anterior gills of ancestral fishes. All vertebrate embryos still develop the anterior gill arches first (as ancestral embryos did) and then transform them during development into jaws (as ancestors did not in retaining the forward gills throughout life). Thus, if the embryonic tissues of chickens still retain any capacity for forming teeth, the epithelium of the anterior gill arches is the place to look.

Kollar and Fisher took the combined embryonic tissue of mouse and chicken and grew it in what might strike readers as a bizarre and unlikely place—the anterior chambers of the eyes of adult nude mice (but where else in an animal's body can one find an open space, filled with liquid that is not circulating?). In ordinary teeth, made by a single animal, the outer enamel layer forms from epithelial tissue and the underlying dentin and bone from mesenchyme. But mesenchyme cannot form dentin (although it can produce bone) unless it can interact directly with epithelium destined to form enamel. (In embryological jargon, epithelium is a necessary inducer, although only mesenchyme can form dentin.)

When Kollar and Fisher grafted mouse mesenchyme alone into the eyes of their experimental animals, no dentin developed, but only spongy bone—the normal product of mesenchyme when deprived of contact with enamel epithelium as an inducer. But among fifty-five combined grafts of mouse mesenchyme and chick epithelium, ten produced dentin. Thus, chick epithelium is still capable of inducing mesenchyme (from another species in another vertebrate class yet!) to form dentin. *Archaeopteryx*, the first bird still possessed teeth, as did severa fossils from the early history of birds But no fossil bird of the past sixt million years has produced teeth while the toothlessness of all moder birds ranks with wings and feather as defining characters of the class Nonetheless, although the system ha not been used on its home groun for perhaps a hundred million generations, chick epithelium can still induce the formation of dentin whe combined with appropriate mesenchyme (chick mesenchyme itself ha probably lost the ability to form dentin, hence the toothlessness of hen and the necessity for using mice).

Kollar and Fisher then found something even more interesting. In fou of their grafts, complete teeth had developed! Chick epithelium had no only induced mouse mesenchyme t form dentin; it had also been abl to generate the enamel matrix proteins. (Dentin must be induced by epithelium, but this epithelium canno differentiate into enamel unless it, i turn, can interact with the very denti it has induced. Since chick mesenchyme cannot form dentin, chick epithelium never gets the chance to show its persistent stuff in nature.)

One final point stunned me ever more. Kollar and Fisher write of thei best tooth: "The entire tooth structur was well formed, with root development in proper relation to the crown but the latter did not have the typica first-molar morphology, since it lacke the cusp pattern usually present i intraocular grafts of first-molar rudiments." In other words, the tooth look normal, but it does not have the form of a mouse's molar. The odd form may, of course, simply result from th peculiar interaction of two systems no meant to be joined in nature. But i it possible that we are seeing, in part the actual form of a latent bird' tooth—the potential structure tha chick epithelium has encoded for sixt million years but has not expresse in the absence of dentin to induc it?

Kollar and Fisher's work recalle another experiment from the opposit end of a chick, a famous story usuall misreported by evolutionary biologist (once, I am embarrassed to say, b myself), as I discovered in trackin down the original source. In 1959, th French embryologist Armand Hamp reported some experiments on the de

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velopment of leg bones in chick embryos. In ancestral reptiles, the tibia and fibula (the bones between your kneecap and ankle) are equal in length; the ankle region below includes a series of small bones. In *Archaeopteryx*, the first bird, tibia and fibula are still equal in length, but the ankle bones below have been reduced to two, one articulating with the tibia, the other with the fibula. In most modern birds, however, the fibula has been reduced to a splint. It never reaches the ankle region, while the two ankle bones are "engulfed" by the rapidly growing tibia and fuse with it. Thus, modern birds develop a single structure (the tibia with ankle bones fused to it and the rudimentary fibula at its side), articulating with bones of the foot below.

Hampé reasoned that the fibula might well maintain its capacity for attaining full, ancestral length, but that competition for material by the rapidly growing tibia mght deprive it of any opportunity to express this potential. He therefore performed three types of experiments, all directed toward giving the fibula some relief from its imperialistic and normally victorious neighboring bone. In all cases, the fibula attained its ancestral length, equal to the tibia and reaching the ankle region below. In the first, Hampé simply grafted more embryonic tissue into the region of the growing leg bones. The tibia reached its characteristic length, but the region now had enough material "left over" for the fibula. In the second, he altered the direction of growth for tibia and fibula so that the two bones did not remain in intimate contact. In the third, he inserted a mica plate between the two bones; the developing tibia could no longer "grab" material from its less vigorous neighbor and the fibula achieved its full length.

Thus, Hampé re-created an ancestral relationship between two bones by a series of simple manipulations. And this alteration engendered an even more interesting consequence. In normal chicks, the fibula begins its growth in contact with one of the small ankle bones below. But as the tibia enlarges and predominates, this contact breaks at about the fifth day of development. The fibula then retreats to form its splint, while the expanding tibia engulfs both ankle bones to form a single structure. In one case during Hampé's manipulations, the two ankle bones remained separate and did not fuse with either tibia or fibula (while both ankle bones fused with the tibia, as usual, in the other leg of the same embryo—an untreated control allowed to develop normally). In this bird, Hampé's simple manipulation not only produced its intended result (expression of an ancestral relationship in leg bones); it also evoked the ancestral pattern of ankle bones as well.

Hampé was able to produce these impressive atavisms by simple manipulations that amount to minor, quantitative changes in timing of development or placement of embryonic tissue. Adding more tissue doesn't simply make a bigger part with the same proportions; it leads to differential growth of one bone (the fibula) and a change in arrangement of the entire ankle area (two ankle bones, articulating separately to tibia and fibula in some cases, rather than a single tibia with ankle bones fused to it).

Developmental patterns of an organism's past persist in latent form. Chicks no longer develop teeth because their own mesenchyme does not form dentin, even though their epithelium can still produce enamel and induce dentin in other animals. Chicks no longer develop separate ankle bones because their fibula no longer keeps pace with the tibia during growth, but the ankle bones develop and retain their identity when fibulas are coaxed to reach their ancestral length. An organism's past not only constrains its future; it also provides as legacy an enormous reservoir of potential for rapid morphological change based upon small genetic alteration.

Charles Darwin constructed his theory as a two-stage process: variation to supply raw material and natural selection to impart direction. It is frequently (and incorrectly) stated that he said little about variation, embarrassed as he was by ignorance about the mechanism of heredity. Many people believe that he simply treated variation as a "black box," something to be assumed, mentioned in passing, and then forgotten. After all, if there is always enough variation for natural selection to use, why worry about its nature and causes?

Yet Darwin was obsessed with variation. In his writings he devoted much more attention to variation than to natural selection, for he knew that no satisfactory theory of major evolutionary change could be constructed until the causes of variation and the empirical rules of its form and amount had been elucidated. His longest book is devoted entirely to problems of variation—the two-volume *Variation of Animals and Plants Under Domestication* (1868). Darwin felt that atavism held the key to many mysteries of variation, and he devoted an entire chapter to it, closing (as I will) with these words:

> The fertilized germ of one of the higher animals . . . is perhaps the most wonderful object in nature. . . . On the doctrine of reversion [atavism] . . . the germ becomes a far more marvellous object, for besides the visible changes which it undergoes, we must believe that it is crowded with invisible characters . . separated by hundreds or even thousands of generations from the present time: and these characters, like those written on paper with invisible ink, lie ready to be evolved whenever the organization is disturbed by certain known or unknown conditions.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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# Winners of Natural History's 80th-Anniversary Photographic Competition

"You're kidding!" was the typical response of the winners of our 1980 Photographic Competition, suggesting that the many entrants (who submitted up to five pictures each) did so with little thought of succeeding. But the mail that piled up in our office was ample evidence that our contestants were cautiously optimistic.

This year our judges were Will Hopkins, former art director of *Look*, who is the art director of *American Photographer* and a consulting editorial art director; Arthur Rothstein, director of photography for *Parade*, the Sunday newspaper magazine, who recently had the distinction of serving as a juror for the 1979 Pulitzer Prize in photography; and Marie Schumann, picture reporter for *Life* and also a freelance picture researcher.

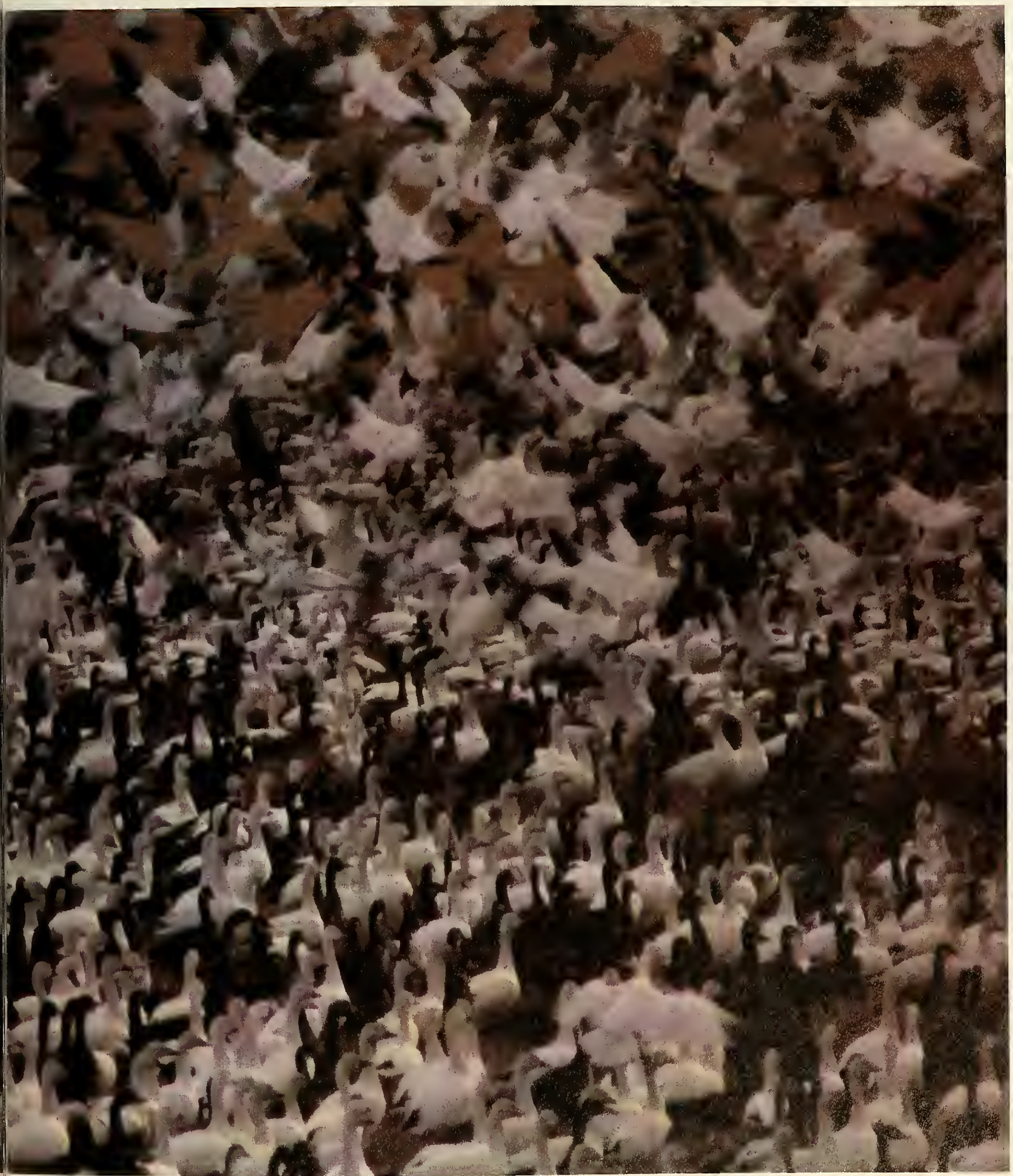
Artistic design figured strongly in the judges' selections; they bestowed the Grand Prize on a beautifully composed photograph of a yucca plant in white sand. First Prize winners were chosen for three major categories—The Human Family; Animals; and Plants and Their Environment—and Merit Awards were given for Photomicrography; A Sequence in Nature; Urban Wildlife; and Humor in Nature. Honorable Mentions were chosen from among all the finalists. The prizewinning photographs will also be exhibited at the Museum this fall.

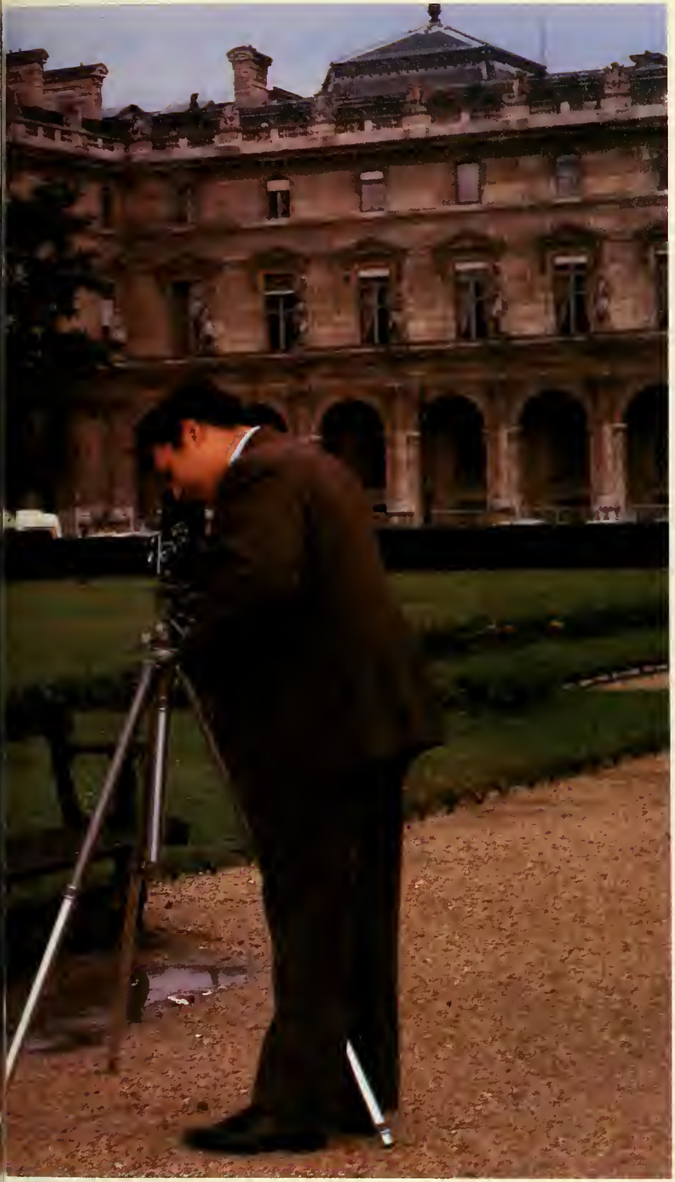
To all who participated, a well-deserved "thank you" and hearty encouragement for next year's contest. The deadline and rules for the 1981 competition, to be announced in a future issue of *Natural History*, will include one important new feature. In place of a Merit Award for Urban Wildlife there will be a special category for photographs more than fifty years old (you need not be the original photographer). So start looking through your family albums and attics for previously unpublished, historical pictures that fit the themes of our contest categories. We look forward to sharing your discoveries.

*Vittorio Maestro*

**FIRST PRIZE**
Animals
**FRANS LANTING**

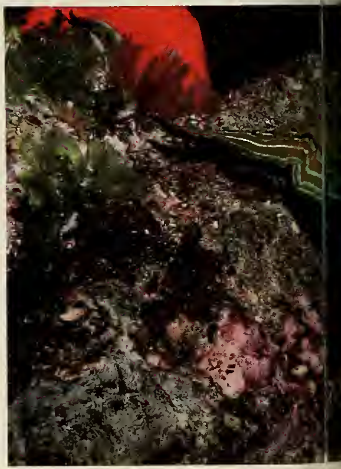
*Snow geese and Canada geese feeding at California's Tule Lake will take off at the slightest provocation. Frans Lanting photographed the birds in the late afternoon of an overcast winter day. He is an instructor in environmental studies at the University of California at Santa Cruz.*

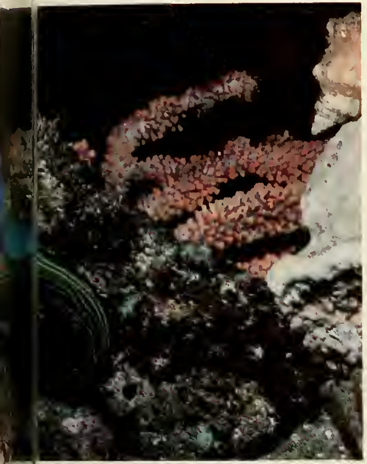




**FIRST PRIZE**
The Human Family
**IRENE BORGER**

*The Louvre in Paris provided the backdrop for this photograph, taken in the summer of 1972 by Irene Borger. A resident of Santa Monica, California, Borger is a dance anthropologist, interested in understanding dance in its cultural context. She also writes about photography, but does only a limited amount herself, as a hobby.*



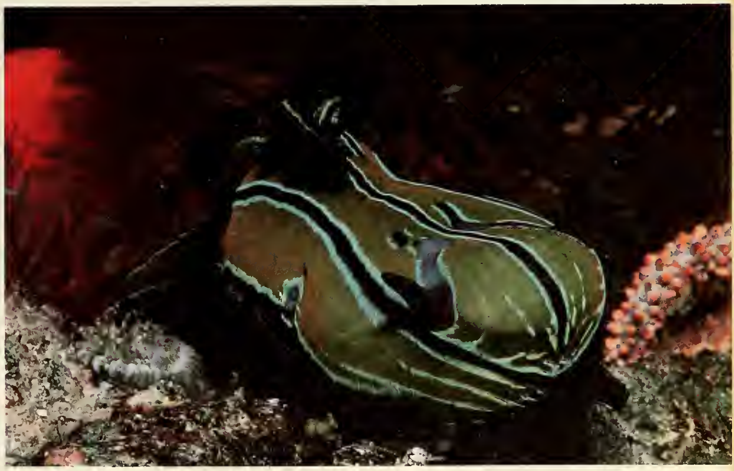


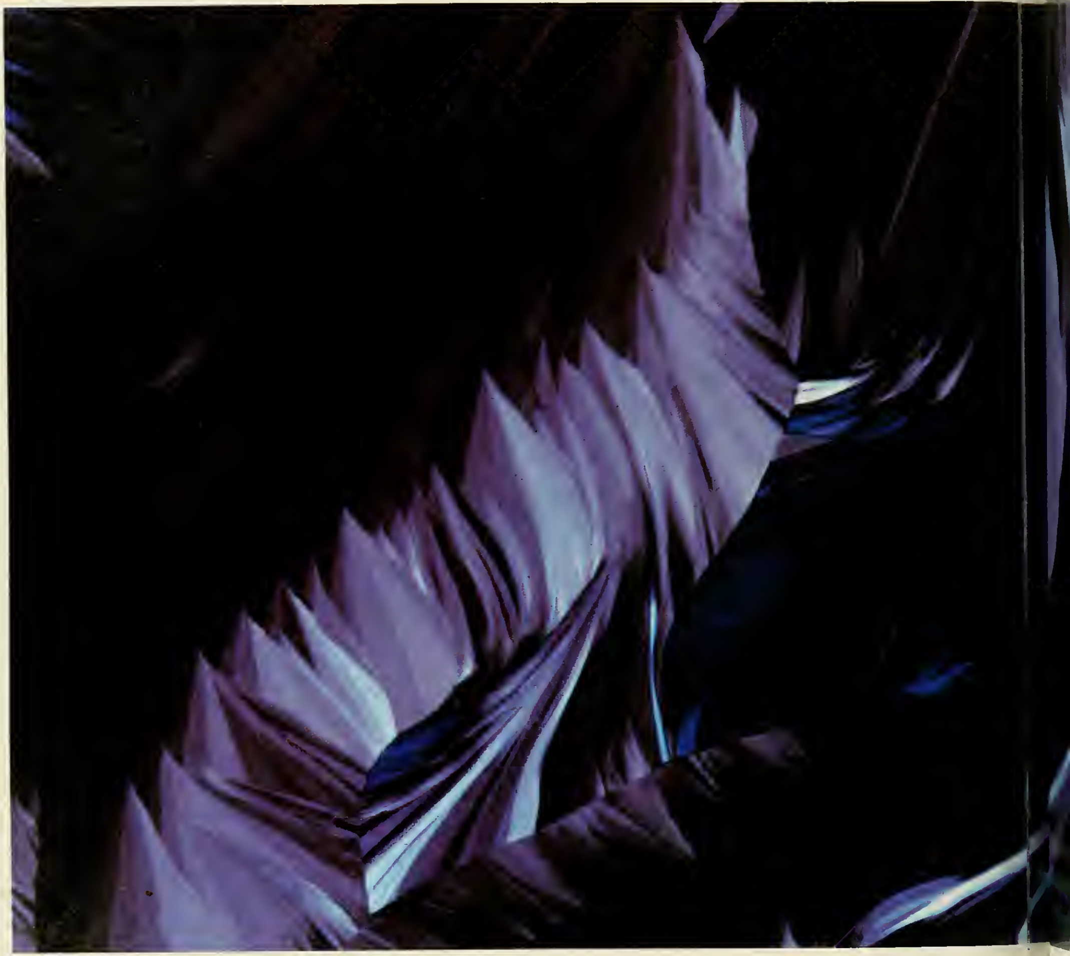
## MERIT AWARD

A Sequence in Nature

**ALEX KERSTITCH**

*Alex Kerstitch first suspected that the sea slug* Roboastra tigris *was cannibalistic when he was diving in the Sea of Cortez. He had collected three specimens in a jar, but when he opened the container, he found only one oversized slug. To witness and record the event in nature, Kerstitch spent more than 100 hours underwater in the Gulf of California, off western Mexico. In this sequence, the smaller sea slug uses its sense of smell to approach the larger individual, probably expecting to make a meal of it. However, the larger sea slug turns on the smaller one, expanding its mouth parts to seize it. The victim is quickly engulfed and within thirty seconds has all but disappeared. One distended sea slug remains, and digestion begins. Although cannibalistic,* R. tigris *appear not to prey on other species of sea slugs, which they avoid. Alex Kerstitch is a research associate in the Department of Ecology and Evolutionary Biology at the University of Arizona, Tucson, and teaches high school art and science.*



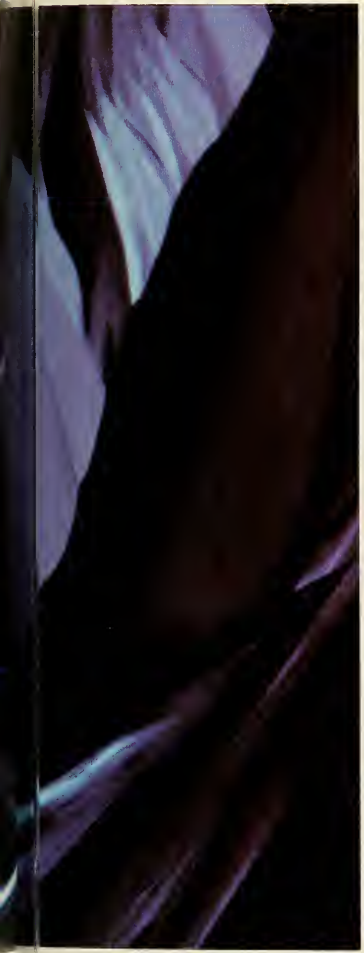


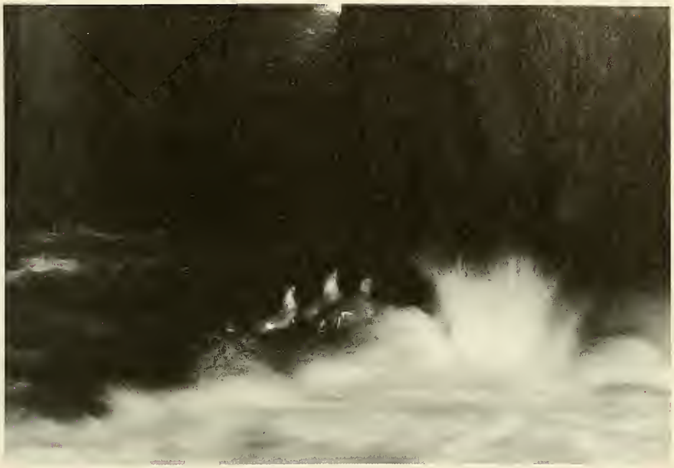
**MERIT AWARD**
Photomicrography
**SUZANNE GROET**

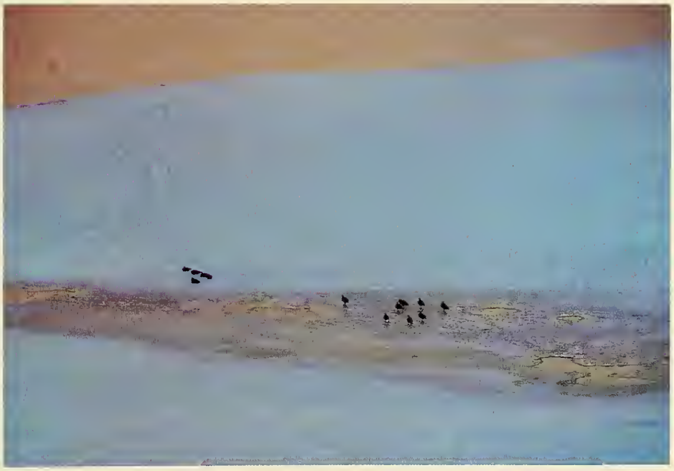
*Suzanne Groet, a botanist living in Upper Arlington, Ohio, has been taking photomicrographs for nearly three years. This one shows a resorcinol "melt crystal," formed when a crystal melts and recrystallizes on a slide. A Leitz Ortholux microscope provided × 32 magnification. Polarized light was used, and the color was modified by a retardation filter.*

**Honorable Mention**
Animals
**Terry Shumaker**

*These Steller's sea lions were photographed by the light coming into their cave near Florence, Oregon. At the time he took the picture, Terry Shumaker was vacationing on the coast. He is a graphic artist living in Medford, Oregon.*





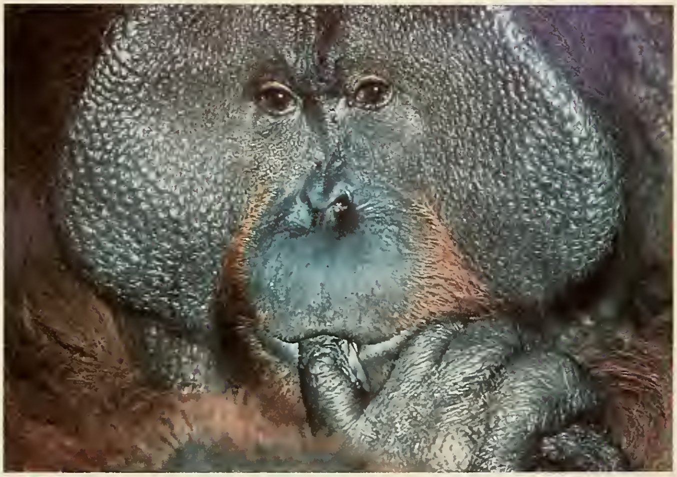


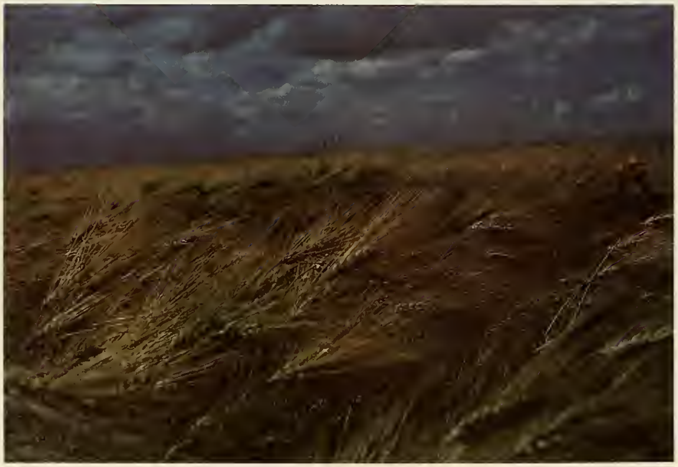
**Honorable Mention**
Animals
**Dene De Nend**

*A view of Canada geese resting on an ice flow greeted Dene De Nend when he pulled up his car one January evening to look over the bank of Idaho's Lake Pend Oreille. De Nend, a free-lance graphic artist who lives in Seattle, takes photographs professionally but is a relative beginner at wildlife photography.*

**HONORABLE MENTION**
Animals
**MILTON NEWMAN**

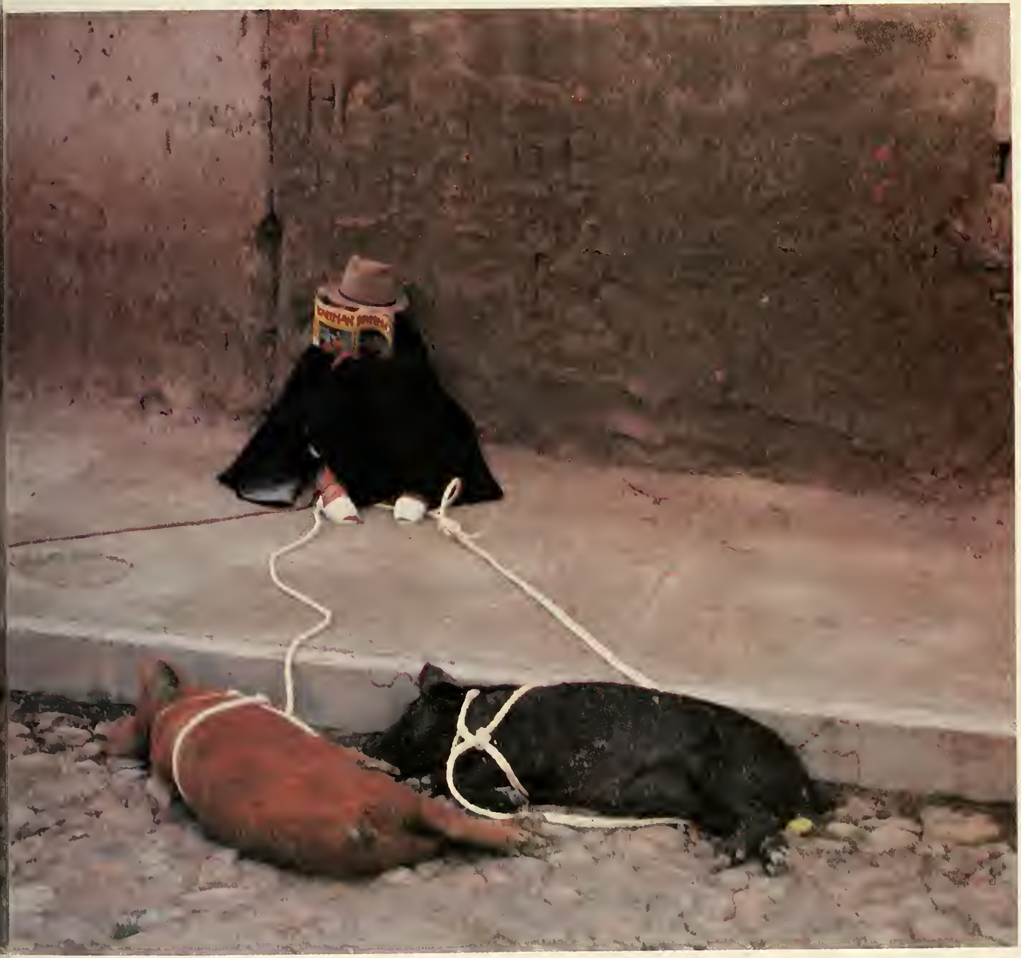
*Milton Newman now lives in California, but he was a New York City resident when he visited this orangutan at the Bronx Zoo. The photograph was taken indoors, with a flash, through the glass wall that separated the photographer from his obliging model. For Newman, a retired designer of display mechanisms, photography is a hobby.*





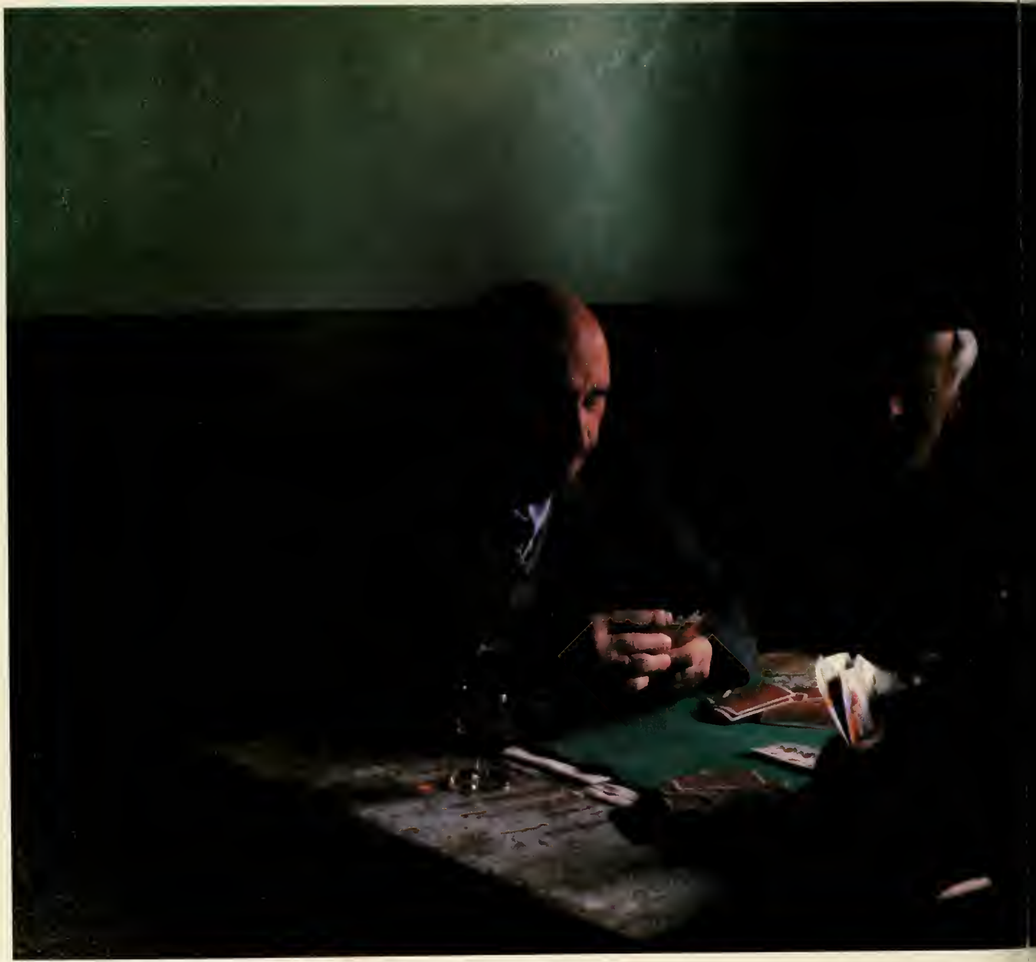
**HONORABLE MENTION**
Plants and Their Environment
**STEVE RAYE**

*Steve Raye, a public relations account executive living in Glendale, Wisconsin, takes photographs to illustrate agricultural magazine articles he writes for clients. In this case, business brought him to a barley field in North Dakota's Red River Valley. To heighten the sense of an approaching storm, Raye used a polarizing filter to enhance the clouds.*



**MERIT AWARD**
Humor in Nature
**RALPH W. SCHREIBER**

*Ralph W. Schreiber, curator of ornithology at the Los Angeles County Museum of Natural History, was leading a tour to the Galápagos Islands when he took this picture in Otavalo, Ecuador. Apparently, this boy was waiting to take the pigs home after he (or his family) had purchased them at the market. He held his comic book in front of his face as his portrait was snapped.*

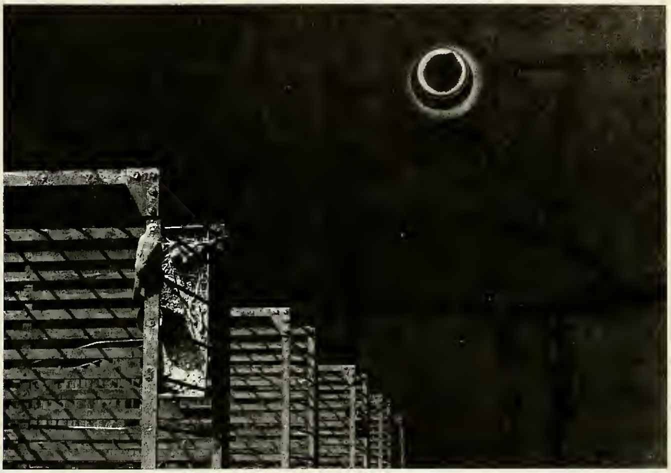


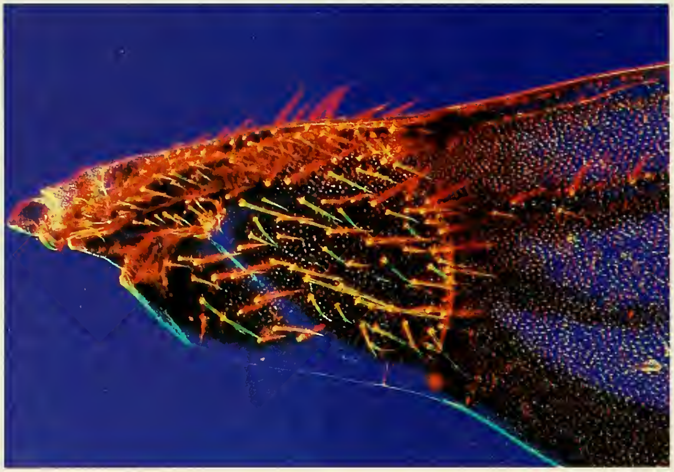
**Honorable Mention**
The Human Family
**Lawrence Spatz**

*In a village near Gijón, on Spain's northern coast, Lawrence Spatz found these card players whiling away a Sunday afternoon at a typical community bar. A clinical chemist, Spatz lives in Lanesboro, Massachusetts. Photography has been a hobby of his for about twenty years; he usually works in black and white.*

**MERIT AWARD**
Urban Wildlife
**Jeanne S. Barnes**

*An unused flower box in Manhattan provided an appropriate nesting place for this pair of mourning doves. The male was perched on the fire-escape railing, standing guard, when Jeanne S. Barnes held her camera out over the edge of a rooftop. Barnes, a secretary in New York City, had been studying 35mm photography for little more than a year when she mailed in her prizewinning entry.*



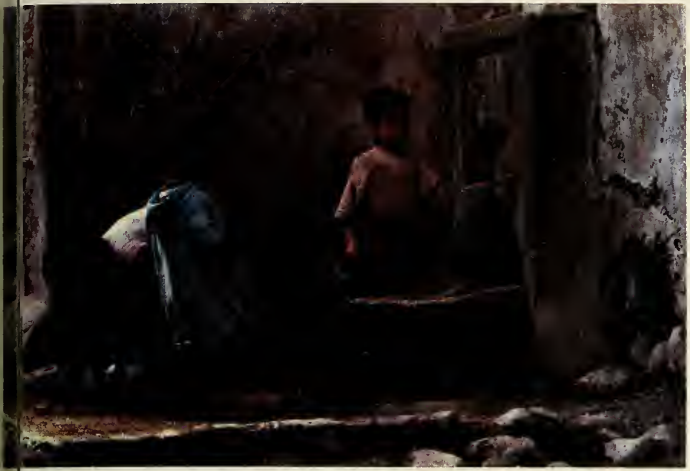


**Honorable Mention**
Photomicrography
**Kent P. Wood**

*This photomicrograph of an insect wing (taken at × 40 magnification) was produced by Kent P. Wood for the oral section of the test to become a registered biological photographer. The illumination effect was created with a "Rheinberg disc," which has a blue central stop and a peripheral ring whose axes are red and green. Wood is a medical photographer at the University of Arizona, Tucson.*

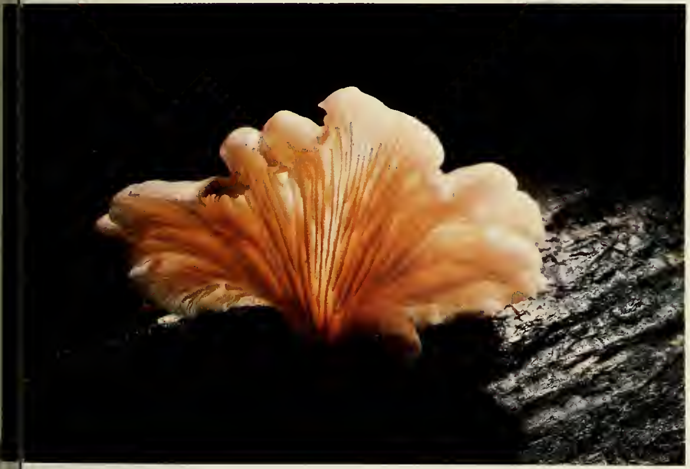
**H ORABLE MENTION**
Pl ts and Their Environment
**R. ILLER VOGEL**

*T leaf at the New York Botanical Garden in the Bronx reminded ar t-photographer R. Miller Vogel of an armored breastplate. Vogel, wl free-lances, took up the camera about nine years ago and has be using it professionally for five or six years. Usually his work in lves such projects as record-album covers and travel materials.*



**HONORABLE MENTION**
The Human Family
**TOM DAMON**

*For Tom Damon, a teacher of earth science living in Colorado Springs, Colorado, this 1959 photograph evokes the time he was stationed at an Air Force base in Morocco. Nearby was the ancient town of Moulay Idris, a holy place for Muslims where "infidels" were allowed to visit but not to stay. According to Damon, the townspeople were reluctant to have their pictures taken—they considered the camera to be an "evil eye"—but the children were not so fearful.*



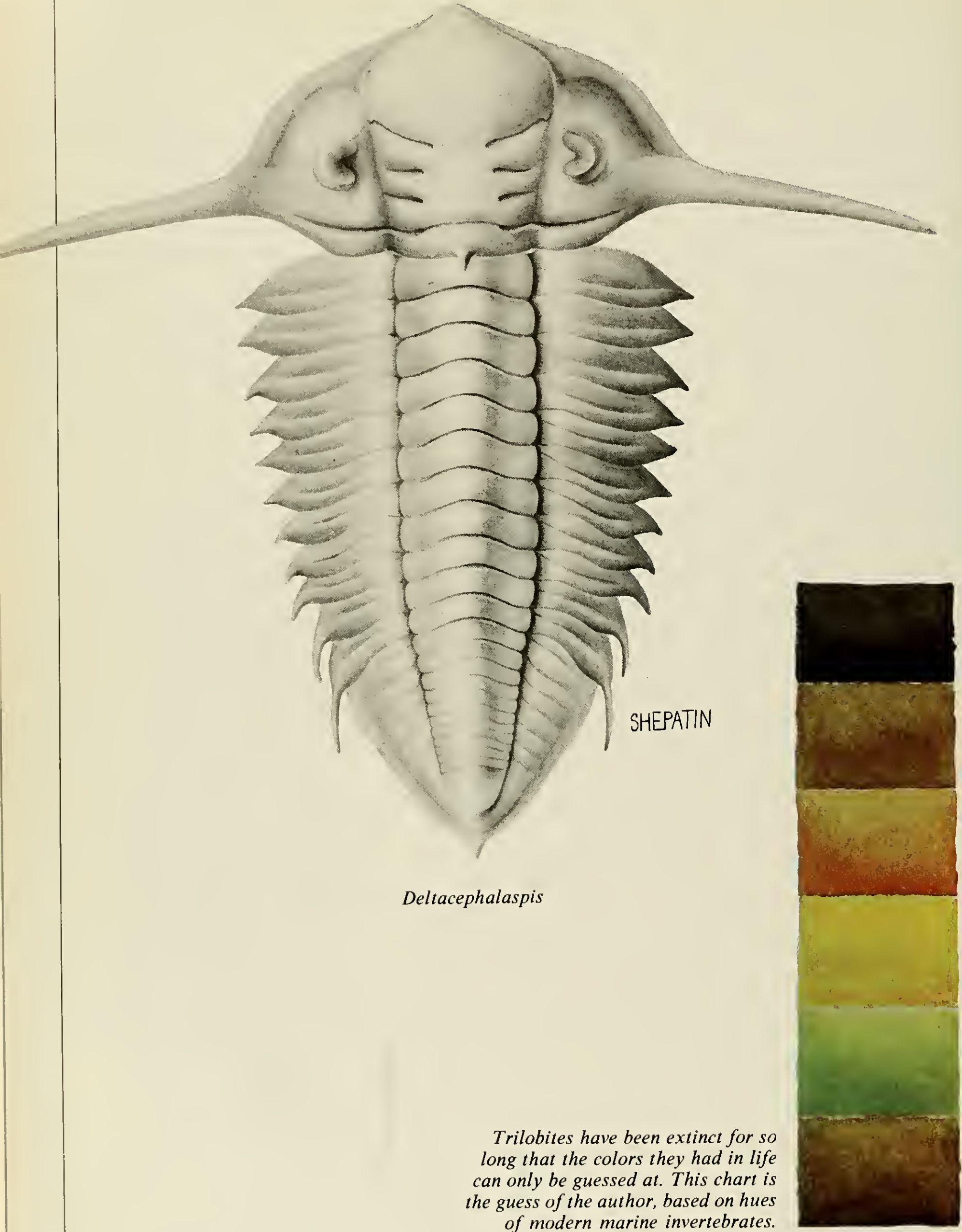
**H ORABLE MENTION**
Pl ts and Their Environment
**RI HARD T. BRYANT**

*A n aquatic ecologist, Richard T. Bryant usually photographs fis but this time his subject was an oyster mushroom on a fa n tree. An electronic flash, held above and to the right by meone else, provided the lighting. The picture was taken at e Roaring Forks Motor Nature Trail in Tennessee's Great Sr ky Mountains National Park.*

## GRAND PRIZE

**C. N. SLOBODCHIKOFF**

*The abstract shape created by a yucca plant, its shadow, and the contrasting gypsum-white sand fascinated C. N. Slobodchikoff. He snapped his Grand Prize-winning picture about five o'clock on a June afternoon in the White Sands (New Mexico) National Monument. Slobodchikoff, an associate professor of biology at Northern Arizona University at Flagstaff, took up photography as a hobby some ten years ago.*



*Deltacephalaspis*

*Trilobites have been extinct for so long that the colors they had in life can only be guessed at. This chart is the guess of the author, based on hues of modern marine invertebrates.*

Illustrations by Marjorie Shepatin

# An Extravagance of Species

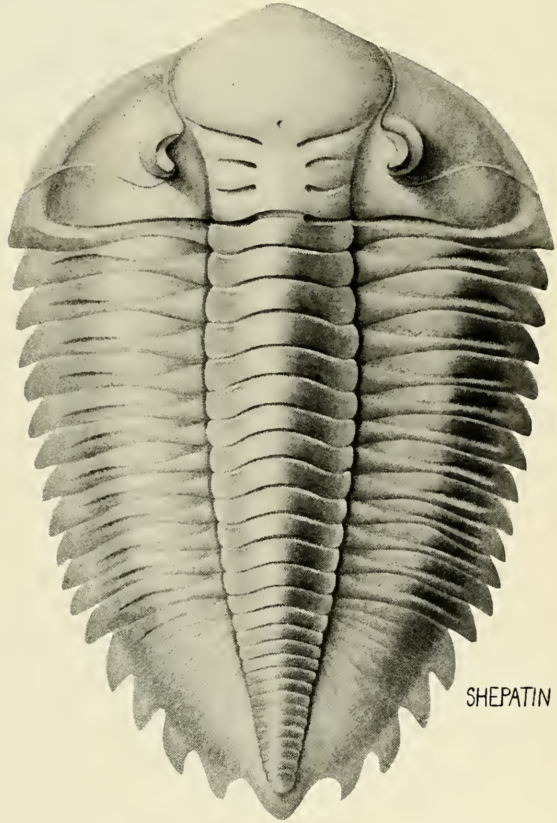
*The diversity of fossil trilobites poses a challenge to traditional evolutionary theory*

**by Niles Eldredge**

In the summer of 1972, a colleague asked me to help with a routine identification of a fossil owned by LeGrand Smith, an American missionary living in Bolivia, who was passing through New York en route to Czechoslovakia with a load of fossils. The single specimen he brought us resembled nothing so much as a rounded lump of hardened clay, and we first pronounced it "inorganic." But a thin ridge with what looked like the lenses of the eye of a trilobite (an extinct relative of crabs and shrimp) finally convinced us that there must be something organic hidden inside.

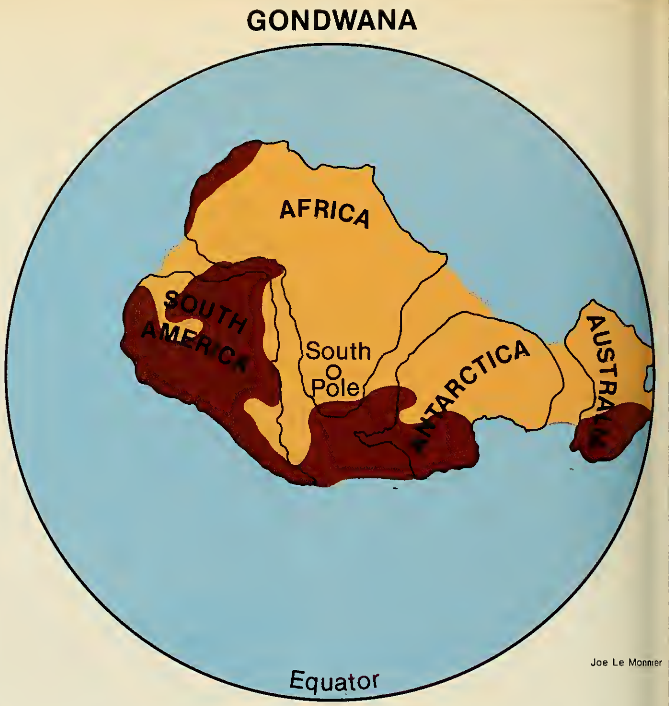
A month of tedious, painstaking preparation with a sharp needle eventually uncovered a fossil, although not a trilobite. It was so odd that we couldn't tell exactly what kind of fossil it was. After some detective work in the literature we finally established that it was an exquisite, uncrushed specimen of a rare proto-horseshoe crab. Only three highly distorted and totally flattened specimens even remotely like the Bolivian creature had ever been seen before. The crushed specimens came from Lower Devonian slates of southern Germany. Because of the excellent preservation of the Bolivian material, anatomical details of this group of early horseshoe crabs were clarified for the first time, which enabled us to reassess the early stages of evolution of horseshoe crabs.

But the really appetizing part of the encounter with Smith was his offhand assertion that he had thousands of Devonian fossils in his collection. His collaborator, Dr. Leonardo Branisa, then of the Bolivian Geological Survey, had amassed a still larger collec-



*Metacryphaeus*

*Scientists believe that about 380 million years ago, Africa, South America, Antarctica, and Australia were part of one unified landmass—Gondwana—which later drifted apart. The brown-shaded areas were shallow seas overlying parts of Gondwana; yellow indicates land; and blue, open sea. The trilobites discussed in the article inhabited these shallow seas; their fossils are now found in parts of South America and the other continents that were once under water.*



Joe Le Monnier

tion and had recently sold several thousand specimens to the Smithsonian Institution. No paleontologist even remotely interested in the fossils of a region could ignore or resist the promise of an open pipeline into what looked like enormous fossil wealth. Smith, Branisa, and I joined forces, and I soon found myself inundated with Bolivian trilobites.

Nothing delights a paleontologist more than confronting a rich collection of well-preserved fossils, and the Devonian rocks of the southern continents, the source of my trilobites, are famous for their fossils. They have been studied sporadically, mostly by northerners, for more than 100 years and until recently seemed fairly well known. Famous collecting sites in Bolivia, Brazil, and South Africa have long since been carefully picked over, and descriptions of their fossils have filled the pages of at least fifty articles and monographs. But now that remoter areas, particularly of the South American Andean Cordillera, are being frequented by fossil hunters, we find that we have only scratched the surface.

A flood of new fossils has easily doubled the number of known species of marine invertebrates. But beyond the simple pleasure of filling a large gap in our knowledge of the history of life, this new fossil material has raised a number of questions about the origin and history of a vast territory of the world and its inhabitants during a forty-million-year period of time that spans the Upper Silurian and Lower Devonian periods, from about 410 to 370 million years ago.

The area involved is the more southerly part of famed Gondwana, the once-unified landmass that drifted apart to become South America, Africa, Antarctica, India, and Australia. And the animals involved are shelled invertebrates—past denizens of shallow marine habitats. Dominant among these invertebrates are the trilobites.

Trilobites, including the ones from Bolivia that I studied, pose some fundamentally important evolutionary puzzles, puzzles whose solutions demand changes in evolutionary theory. It would be tempting to offer a scientific detective story of my work, with patterns in the raw data suddenly emerging to suggest a new theory. But no scientist ever accumulates facts blindly. There are always new ideas emerging that influence the way we look at new, and old, facts.

When I first became aware of the Devonian trilobites of the Southern Hemisphere, new ideas of the earth's history, such as the notion of continental drift, were in the breeze. These ideas were having their effect in other areas, particularly on explanations of how animal and plant distributions change through time (historical biogeography). And I was entranced with a new and, in some respects, radically different way of thinking about the evolutionary process that questions the role of natural selection in creating new species.

Theoretical ferment on evolution in the Southern Hemisphere is not new. The history of research in the ancient geography and the fossil animals of the southern continents has been tortuous and filled with controversy. To begin with, the notion that Africa and South America were previously joined has only recently gained widespread acceptance. For years, just a few solitary voices supported this idea, including those of the South African Alexander du Toit and the American Kenneth Caster, both of whom were familiar with the similarity between the fossil faunas of South America and southern Africa. Others believed the continents had always been far apart.

Depending on which view of geographical history is adopted (stable continents always separated or Gondwana now fragmented), paleontologists naturally develop rather different ideas about the history of distributions of animals and plants. If the pattern to be explained is the presence of similar organisms on two forever widely separated continents, our explanation invokes long-distance dispersal over the barrier of the South Atlantic. For marine invertebrates, we must invoke current patterns capable of wafting larvae long distances. The invention of these current patterns sometimes stretches he principles of oceanography beyond endurance.

Dispersal need not be invoked if we let the continents do the moving. In his approach, major changes in the distributions of organisms over the globe are passive reflections of actual changes in the physical geography itself.

Thus we have two conflicting sets of explanations for historical changes in animal and plant distributions; both have come into play in the analysis of the history of the 380-million-year-old fossils from the Southern Hemisphere. Now there is a consensus that the similar fossil faunas scattered over the southern continents reflect fragmentation of Gondwana rather than long-range larval dispersal.

What is the evolutionary history of he Gondwana trilobites? Most, roughly thirty of fifty genera, belong o the Calmoniidae, a single family hat occurs nowhere else and whose numbers offer an excellent chance to look for evolutionary patterns.

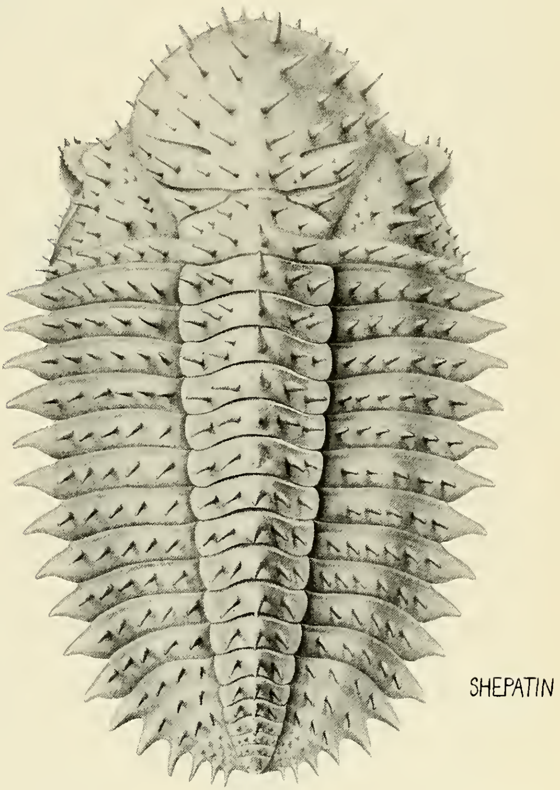
Apart from their dominance, the calmoniid trilobites are a fascinating lot. Derived from a garden variety, run-of-the-mill simple form, the sixty or so species known to date diversified into one of the more spectacular radiations of the entire 400-million-year history of trilobites. A few retained the general ancestral simple form. But most modified the old form, and some became, even by trilobite standards, downright bizarre. I have calmoniids with spines added to the front, or to the sides and middle of the head, or around the margins of the tail. I have others up to seven inches long—quite a length for a trilobite, most of which are less than one and a half inches long.

One group, which seems to be natural (meaning that all its members are closely related and form a single sublineage of the family), invented a unique anatomical plan. The genera in his group do not resemble any other kind of trilobite particularly closely. They are immediately identifiable as unique forms. *Deltacephalaspis*—the long name simply means "triangular-shaped head with spine"—is both typical of this group and highly unusual for trilobites in general. The immense spines sticking out from both sides of he head are particularly noteworthy. To guess with any certainty about how trilobites lived is difficult in itself, as their appendages, used for food gathering and locomotion, are almost never preserved. But I am totally at a loss to explain strange structures like the pair of enormous, hornlike spines on either side of the head of *Deltacephalaspis*.

The spines could have been stabilizing structures used in swimming or in righting the animal if it were ever tipped over. (Think of the difficulty a wingless insect has in getting back on its feet after falling on its back.) But with no clear living analogs, such speculation, however entertaining, is fruitless. For *Deltacephalaspis* and its relatives (such as the spine-snouted *Schizostylus* and *Cryphaeoides*), we must be content with just describing the array of different kinds, assuming that there were functional reasons underlying their evolutionary development.

The evolutionary pattern of diversification in the other major calmoniid group is more readily explained—at least in general terms. Also evolutionarily natural and coherent, this group shows, if anything, an even greater range of anatomical configurations than the first. But the kinds of anatomical modifications developed by members of this group are rather familiar. They are reminiscent of trilobites in other families. *Bouleia dagincourti*, for instance, is similar to *Phacops*, a trilobite that is also found in Gondwana.

I stumbled on this similarity before I became deeply involved with the Bolivian fossils. At the time, I was working on *Phacops* (see "A Trilobite Odyssey," *Natural History*, October 1972). Browsing through the trilobite collections at the American Museum of Natural History, I found a particu-



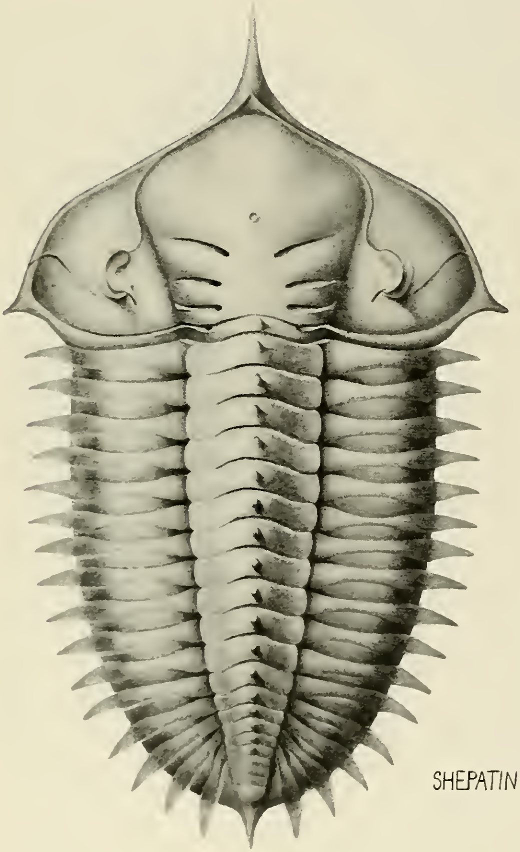
*Bouleia*

larly beautiful specimen of *Bouleia*, which was said to be closely related to *Phacops*. The specimen was well enough preserved to show that its resemblance to *Phacops* was entirely superficial. The only special similarities between them were a large, bulbous head and a small, rounded tail. Here, apparently, was a case of evolutionary convergence, in which remotely related organisms evolve somewhat similar structures, adapting to similar environmental demands.

In this second group of calmoniids there are several examples of convergence. *Metacryphaeus*, a calmoniid, is very much like the dalmanitid trilobites common in Devonian faunas elsewhere in the world. Another case of convergence is the similarity of *Schizostylus*, with its long snout and cheek spines, to the rare *Probolops*, both calmoniids. The head of *Probolops* is modified into exactly the same form as *Schizostylus*. Since the two are found in the same beds and *Probolops* is extremely rare, it may well have gained some advantage by mimicking *Schizostylus*.

Such similarities offer some insight into the evolutionary history of the Gondwana trilobites. But we are left to explain the most striking fact about these fossils—their diversity. What does all this variety suggest? How and why did ancestral trilobites evolve into so many kinds of descendants, so anatomically varied?

Standard evolutionary theory focuses on anatomical change through time by picturing natural selection as the agent that preserves the best of the designs available for coping with the environment. This generation by generation process, working on small amounts of variation, is thought to change, slowly but inexorably, the genetic and anatomical makeup of a population.



*Cryphaeoides*

If this theory were correct, then I should have found evidence of this smooth progression in the vast numbers of Bolivian fossil trilobites I studied. I should have found species gradually changing through time, with smoothly intermediate forms connecting descendant species to their ancestors.

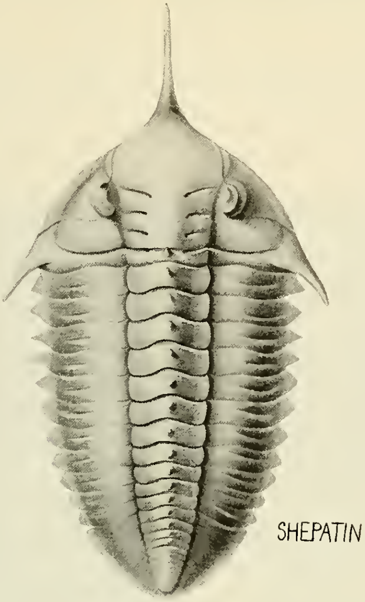
Instead I found most of the various kinds, including some unique and advanced ones, present in the earliest-known fossil beds. Species persisted for long periods of time without change. When they were replaced by similar, related (presumably descendant) species, I saw no gradual change in the older species that would have allowed me to predict the anatomical features of its younger relative.

The story of anatomical change through time that I read in the Devonian trilobites of Gondwana is similar to the picture emerging elsewhere in the fossil record: long periods of little or no change, followed by the appearance of anatomically modified descendants, usually with no smoothly intergradational forms in evidence.

If the evidence conflicts with theoretical predictions, something must be wrong with the theory. But for years the apparent lack of progressive change within fossil species has been ignored or else the evidence—*not* the theory—has been attacked. Attempts to salvage evolutionary theory have been made by claiming that the pattern of stepwise change usually seen in fossils reflects a poor, spotty fossil record. Were the record sufficiently complete, goes the claim, we would see the expected pattern of gradational change. But there are too many examples of this pattern of stepwise change to ignore it any longer. It is time to reexamine evolutionary theory itself.

There is probably little wrong with the notion of natural selection as a means of modifying the genetics of a species through time, although it is difficult to put it to the test. But the predicted gradual accumulation of change within species is seldom (if ever) encountered in our practical experience with the fossil record.

The problem appears to be this: focusing attention purely on anatomical



*Schizostylus*

(and underlying genetic) change ignores a fundamental feature of nature—the existence of species. Species are reproductive communities. They are held together by a network of parental ancestry and descent and separated from other, similar networks of parentage. They are coherent entities in space and—and this is the crucial part—through time as well. Species have origins, histories, and extinctions. They may or may not give rise to one or more descendant species during the course of their own existence.

The internal cohesion of a species predicts the sort of lack of anatomical change during its history that we see so often in the fossil record. And speciation, the process of creating a new, descendant reproductive community from an ancestral one—in a way other than that proposed by natural selection—must be a crucial step in the evolutionary process.

There are three or four commonly accepted, slightly different notions on how speciation occurs. The most favored theory of speciation for active, complex animals such as trilobites is geographical, or allopatric, speciation—what nineteenth-century biologists called vicariance. The basic idea of this model is simple: the easiest way to achieve reproductive independence between an ancestral species and its descendant is to segregate a segment from the main part of the ancestral species. Speciation occurs if enough behavioral or anatomical differences develop to guarantee that the two species will not hybridize should they one day come to inhabit the same area.

Other speciation theories hypothesize ways in which a new reproductive community—a fledgling species—can bud off from its parent without being isolated geographically as an initial step. But none of the various theories see *natural selection* changing a species' adaptations enough to develop a "new" species from an old one. Rather, speciation is a largely accidental fragmentation of a once coherent reproductive community.

During such events, behavioral, anatomical, and genetic change (sometimes quite rapid) may occur. Such change must occur if we are to be able to tell the daughter species from the parent. And the process of natural selection must account for part of such change. But natural selection per se does not work to create new species. The pattern of change in so many examples in the fossil record is far more a reflection of the origin and differential survival (selective extinction) of species than the inexorable accumulation of minute changes within species through the agency of natural selection.

The evolutionary pattern of the calmoniid trilobites is decisive: an evolutionary theory that maintains the primacy of pure natural selection and entertains no other mode of change is incomplete. In fact, the Devonian trilobites of Gondwana support, on several levels, the importance of geographical differentiation and speciation emphasized so long ago by Darwin and some of his contemporaries. First, speciation is the key to understanding the pattern of anatomical change actually seen in the fossil record. Since geographical isolation is the simplest way to bud off a descendant from an ancestral species, we look for adjacent regions harboring slightly different, closely related races and species. Within Bolivia itself, there is a pattern of geographical variation from north to south among many of the calmoniid species.

On a grosser level, three major subregions of the Devonian Gondwanan province can be recognized, each with its characteristic assemblage of species related to, but usually not the same as, those in the other subregions. Patterns of relationship among the species of calmoniids indicate that the Andean subregion may be more closely affiliated with southern Africa than either is with the stable continental interior subregion of South America. The Gondwanan map shows a possible explanation for this pattern: current patterns reconstructed on the basis of principles of physical oceanography indicate a more complete connection between the Andes and southern Africa than between either of those areas and continental South America.

Finally we return to the grand pattern we took up at the outset: the entire Gondwanan province is unique. It is an area that was so isolated from the rest of the world that it peopled its seas almost entirely with its own home-grown products. There is no clearer picture of the relation between geography and evolution than the pattern of the origin, history, and demise of the Devonian trilobites of ancient Gondwana. □

# Those Salmon Keep Butting Those Dams

*The Columbia River has become a virtual lake as dam after dam impedes its flow. For the salmon that spawn in the river, the dams may be insurmountable obstacles*

**by Anthony Netboy**

In April 1978, Herman J. McDevitt, a member of the Pacific Fishery Management Council, requested that the National Marine Fisheries Service review the status of the rapidly declining spring and summer chinook salmon runs in his home state of Idaho. The inquiry, under the Endangered Species Act, was later widened to include all salmon species in the streams above the confluence of the Columbia and Snake rivers. If after public hearings it is found that one or more of the upper river species are in danger of extinction, the federal government, along with the states involved, would be required to develop protective regulations "necessary and advisable for conservation of the species."

Endangered listing would automatically prohibit the taking of the species until stocks are built back—a process that could take years. It would also throw a monkey wrench into the operation of upper river hydroprojects, which have depleted the salmon stocks by usurping the water flow needed for the migration of these fish.

How did the Columbia, one of the world's richest salmon rivers, come to this pass?

The early explorers of this region found a wilderness whose rivers teemed with fishes, of which the salmon and steelhead trout (the Pacific version of the Atlantic salmon) were the largest and most numerous. The *Journals* of Lewis and Clark describe with considerable detail the scenery, inhabitants, rivers, and especially the wildlife they encountered in 1805 and 1806. In one day's sailing down the Columbia they passed twenty-nine lodges below the entrance of the Snake River, its major tributary, where Indians were catching and drying salmon. Outside nearly every lodge hung racks of drying fish. In some places the Indians were making pemmican (pounded, dried salmon) and packing it in baskets made of grass and rushes and lined with the dried skins of large salmon. These 90- to 100-pound baskets were not only the major item in the Indians' winter supply of protein food but also the chief article of commerce with distant tribes. At one village Clark counted 107 such baskets containing at least 10,000 pounds of pemmican.

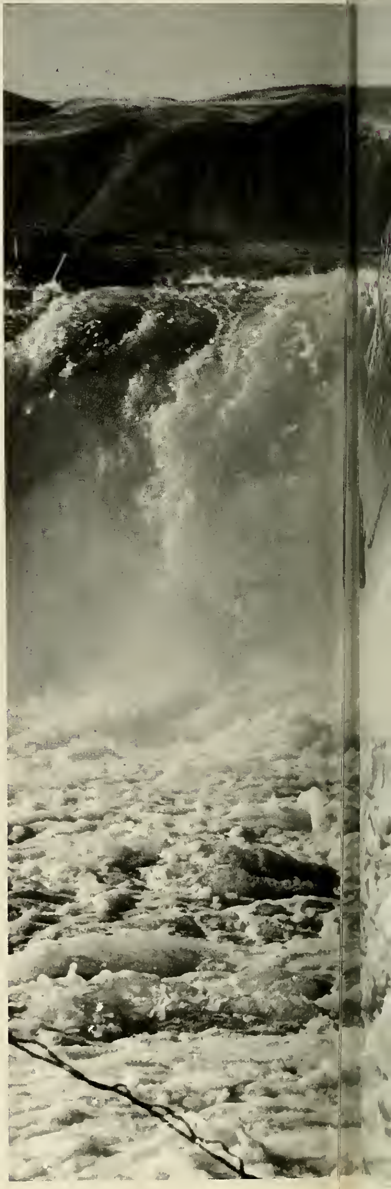
Lewis and Clark recorded more than a hundred sites where the Indians fished for salmon with a variety of gear. Catches were ample, especially at waterfalls, where salmon leaped up from the churning water and Indians with dip nets fished from treacherous rocks. The fish runs continued from April to October.

The salmon were the Indians' staff of life. These torpedo-shaped fish returned with astonishing regularity to the same streams every year. "What was more logical,"says anthropologist Philip Drucker, "than to imagine that they ascended the rivers to benefit mankind, died, and returned to life?"

Thus arose the belief that salmon

> were a race of supernatural beings who dwelt in a great house under the sea. They went about in human form, feasting and dancing like people. When the time came for the "run" the salmon people dressed themselves in salmon flesh, that is, assumed the form of fish to sacrifice themselves. Once dead, the spirit of each fish returned to the house beneath the sea.

To show their gratitude, joy, and relief, the Indians greeted the arrival of the first fish in the spring with prayers and incantations, for if the fish did not appear in sufficient numbers, hunger was sure to follow. Virtually every tribe that lived along the rivers from Bristol Bay, Alaska, to Monterey Bay, California, developed



*Netting salmon at Celilo Falls is a thing of the past. Construction of The Dalles dam ten miles downstream has flooded this once turbulent and productive stretch of the Columbia River.*

Ray Atkeson

LIFE HISTORY OF THE COLUMBIA RIVER SALMON AND STEELHEAD TROUT

| Common name | Chinook, King | Blueback, Sockeye, Red | Chum, Dog | Silver, Coho | Steelhead Trout |
|---|---|---|---|---|---|
| Length of freshwater life | few days–2 yr | few days–3 yr | few days | 1–2 yr | 2 yr |
| Length of ocean life | 1–5 yr | ½–4 yr | ½–4 yr | ½–1½ yr | 2 yr |
| Length at maturity | 3 ft | 15–33 in. | 25 in. | 24 in. | 26–28 in. |
| Weight at maturity | 22 lb | 5–7 lb | 8–9 lb | 10 lb | 6–8 lb |
| Spawning months | Aug.–Sept. | July–Sept. | Sept.–Nov. | Sept.–Dec. | Feb.–May |
| Female Fecundity (Number of eggs) | 5,000 | 4,000 | 3,000 | 3,500 | 3,000–3,500 |

rituals and taboos in handling and eating the first arrivals, as a means of propitiating them and their spirits.

The Indians apparently did not know that salmon are anadromous. Born in freshwater, where they remain anywhere from a few weeks to two or three years, salmon head for the ocean when they weigh only a few ounces. Biologists believe the salmon follow routes inherited from their ancestors and imprinted in their chromosomes. Their extensive ocean peregrinations may cover thousands of miles, but when they feel the mating urge, salmon head for their home rivers where they will spawn—and die. (Some steelheads survive and return to the sea.)

After the Indians were relocated to reservations in the mid-nineteenth century, large-scale commercial fisheries arose on the Columbia. The first cannery in the region—at Eagle Cliff on the Washington side of the river—was built in 1865 by Andrew Hapgood and the Hume brothers, all from Maine. That year they handpacked 4,000 cases of 48 one-pound cans of salmon; the next year, 18,000 cases. Competitors soon moved in to exploit the "river of gold."

As demand for this inexpensive, nutritious food developed in the United States, Europe, and South America, industry expanded to satisfy it—on the Columbia, Sacramento, and Fraser rivers, in Puget Sound, and in many Alaskan streams. By 1889 thirty-nine canneries on the Columbia and some of its tributaries were packing 630,000 cases a year.

In the heyday of the fishery an armada of fishing boats plied the Columbia from Astoria to Celilo Falls and beyond. In 1889 twenty-six hundred rowboats and sailboats fished for salmon in an area of about 150 miles, while purse seines, traps, setnets, dip nets, and most efficient of all, huge fish wheels caught additional thousands of fish a day.

Fishing was unrestrained. When reliable gasoline motors came along, in about 1912, many fishermen found they could catch more fish in the ocean beyond the treacherous Columbia Bar than in the river. From 1875 to 1920 annual catches averaged thirty to forty million pounds. At first only the hefty chinook, weighing from twelve to fifty and even one hundred pounds, were taken. When this species began to decline in the 1890s, fishermen hauled in the smaller species: silvers, or coho, weighing on the average ten to twelve pounds; chum, or dog salmon, eight to nine pounds; and red, or sockeye, salmon, five to seven pounds and regarded as the prime canning fish because of its deep red color and succulent flesh.

There were no minimum sizes to which fishermen had to adhere. What state regulations existed could not be enforced because of insufficient funds—only three wardens were available in the entire state of Oregon. One is therefore not surprised to read in the annual report for 1894 of the Oregon Fish Protector:

> It is only a matter of a few years under present conditions when the chinook will be as scarce as the beaver that once was so plentiful in our streams. . . . For a third of a century Oregon has drawn wealth from her streams but now by reason of her wastefulness and lack of intelligent provision for the future, the source of that wealth is disappearing and is threatened with annihilation.

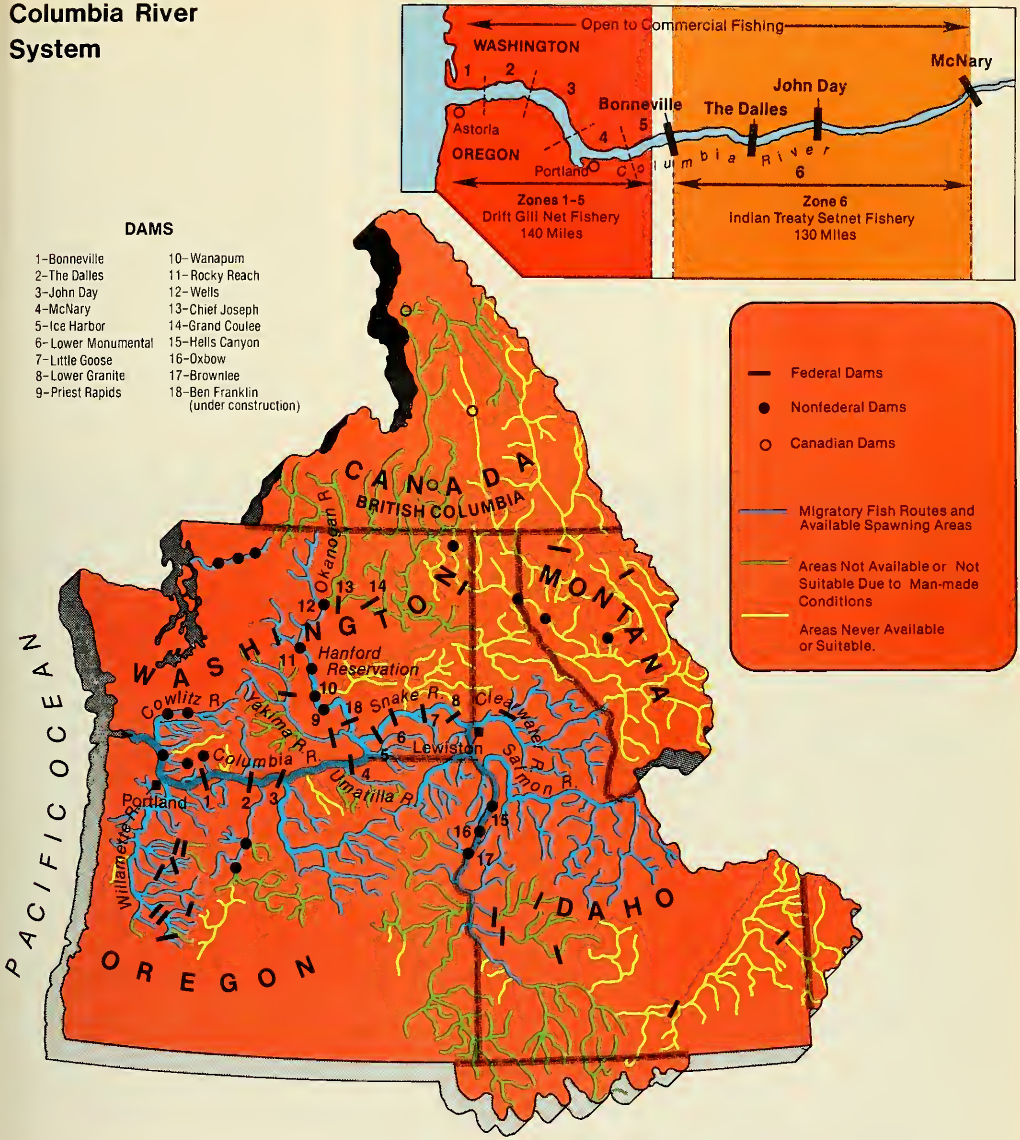
It took a long time for the states of Oregon and Washington, which jointly manage the Columbia River fishery, to heed these prophetic words and take steps to slow down the pace of exploitation by outlawing the most effective gear—fish wheels, weirs, traps, and purse seines—reduce the size of gill nets and mesh, and curtail fishing seasons. Ultimately salmon fishing was limited to gill netting in the rivers, and trolling, a hook-and-line technique, in the ocean. All fixed gear was banned except for setnets, which by treaty rights only Indians may use on the Columbia.

By 1938, when 65-foot-high Bonneville Dam was completed, the fishery had already been considerably reduced by overfishing and much of the salmon's habitat in the vast watershed had been impaired by the clear-cutting of forests, by poor farming and grazing practices that caused soil erosion and siltation of streams, by logjams and logging dams, and by forest fires. Most harmful of all were the huge dams for irrigation, which were built without any consideration of the needs of migrating fish, and unscreened irrigation canals, which lured hordes of young fish to their death.

President Theodore Roosevelt in his *Autobiography* hailed the projects spawned by the passage of the Reclamation Act of 1902 as among the major achievements of his administration but ignored the damage they did to fish stocks. He said, "Many of the dams required for these huge tasks are higher than any previously built anywhere in the world. They feed main-line canals over 7,000 miles in length."

In *Development of the Water Resources of the Columbia River*, a comprehensive report published in 1947, the Bureau of Reclamation admitted "that much of the earlier development of water resources for the essential irrigation of lands in the Central Snake Basin was undertaken without full recognition of the significance of the salmon runs, or of the means to preserve them." As a result, "the volume of the runs has been reduced," a classic understatement. The report contained a map showing the extensive spawning areas already lost, including 1,100 linear miles in northern Washington and British Columbia blockaded by Grand Coulee Dam. When Grand Coulee became operational in 1942, it was the largest dam in the world, and no feasible means had been devised for getting salmon over a bar-

## Columbia River System



DAMS
1-Bonneville
2-The Dalles
3-John Day
4-McNary
5-Ice Harbor
6-Lower Monumental
7-Little Goose
8-Lower Granite
9-Priest Rapids
10-Wanapum
11-Rocky Reach
12-Wells
13-Chief Joseph
14-Grand Coulee
15-Hells Canyon
16-Oxbow
17-Brownlee
18-Ben Franklin (under construction)
Open to Commercial Fishing
WASHINGTON
OREGON
Astoria
Portland
Bonneville
The Dalles
John Day
McNary
Columbia River
Zones 1-5
Drift Gill Net Fishery
140 Miles
Zone 6
Indian Treaty Setnet Fishery
130 Miles
Federal Dams
Nonfederal Dams
Canadian Dams
Migratory Fish Routes and Available Spawning Areas
Areas Not Available or Not Suitable Due to Man-made Conditions
Areas Never Available or Suiteble.
CANADA
BRITISH COLUMBIA
WASHINGTON
MONTANA
IDAHO
OREGON
PACIFIC OCEAN
Okanogan R.
Hanford Reservation
Cowlitz R.
Yakima R.
Columbia R.
Snake R.
Clearwater R.
Salmon R.
Umatilla R.
Willamette R.
Lewiston
Portland

Joe Le Monnier

ricade 550 feet high, 4,173 feet long.

The completion of Bonneville Dam in 1938 had marked a new era in the history of the Columbia fishery. When designs for this multipurpose project were first published by the Army Corps of Engineers, no provisions had been made for fish passage. When this "oversight" was brought to the attention of the chief of the Corps, he allegedly said, "We do not intend to play nursemaid to the fish." Protests by the fishing industry and conservationists changed his mind, and the 65-foot megalith was provided with the most ingenious system of fish ladders, locks, and bypasses ever devised anywhere in the world. The fate of the greater part of the Columbia's anadromous fish runs depended upon the success of this novel system.

Milo Bell, the fishery engineer who, with the late Harlan Holmes of the Bureau of Fisheries, designed the ladders, wrote to me in 1970:

> Little was known of the number of fish that we might be expected to handle at the dam and only limited knowledge of the downstream migration that might be expected. It was assumed that the fingerlings would go over the spillway if their migration coincided with the period of high water that was in excess of power needs and would be allowed to spill; otherwise they would have to pass through the turbine blades in the power house. Passage through turbines was almost completely an unknown subject.

The upstream-migrating adults would be directed by means of powerful jets of water into the curving ladders, one on the Washington side of the dam and another on Bradford Island adjoining the powerhouse. After the fish were in the reservoir an attendant opened a gate and the fish continued their voyage upstream. "If you were a gambling man," said Bell, "you could have found some odds that the whole facility would not have been completely fuhctional."

*Aglow with lights that emphasize its engineering wizardry, Grand Coulee Dam blocks the Columbia River in Washington, diverting part of its flow to irrigation projects.*

The ladders went into operation in the spring of 1938 and the entire fishing industry watched with trepidation. But the canny fish found the entrances with seemingly little hesitation or loss. More than a million fish scaled the ladders that year, of which 470,000 were salmonids. In 1939, 522,000 were counted at the dam; in 1940, 740,000; in 1941, 670,000; and in 1942, 625,000. The large return of adults in 1942 was particularly gratifying because that year marked the end of the four-year chinook and red salmon cycle, indicating that the juveniles of these species, which went downstream in 1938 and 1939, over the spillway or through the revolving blades of the turbines, survived in respectable numbers, reached the ocean, and eventually returned as spawners. The Bonneville ladders were hailed in fishery circles around the world as a miracle of engineering and soon became a tourist attraction.

Although a study by the U.S. Fish and Wildlife Service in the late 1940s showed that up to 15 percent of the fingerlings and a smaller percentage of the adults were killed at the dam, the Corps of Engineers and the electric power industry, especially the public power agencies that had first call on Bonneville generation, proclaimed, "We can have fish and power, too!" This slogan, although challenged more and more as additional dams were constructed on the rivers, generally persuaded the people of the Pacific Northwest to accept the almost complete damming of the Columbia and Snake rivers.

The Corps of Engineers pushed hard to have Congress authorize mainstem dams proposed in its famous "308 Report," first published in the 1920s and subsequently expanded. The Corps had surveyed every stream in the United States portion of the watershed that could feasibly be harnessed for power, navigation, irrigation, and allied benefits. In a similar study by the Bureau of Reclamation, the focus was on irrigation possibilities, the costs to be partly repaid by power generation, as at Grand Coulee, which has provided water to fructify about 500,000 acres in Washington.

The alarmed fishing industry demanded a moratorium on dam construction until more was known about the effects of Bonneville on the fish runs. The Fish and Wildlife Service's

Ray Atkeson

Ray Atkeson

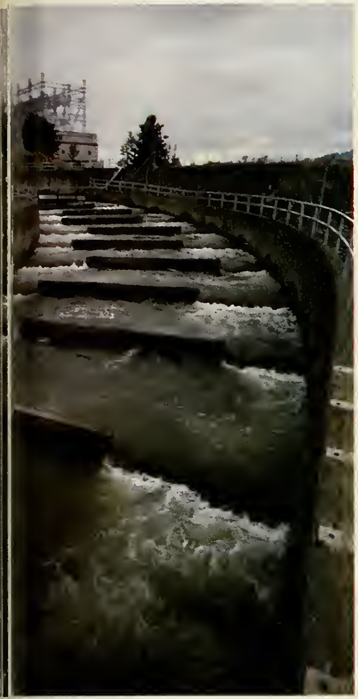
report was suppressed by the Secretary of the Interior, but its findings leaked out. The Columbia Basin Interagency Committee (CBIAC), consisting of the governors of all the basin states, held a hearing at Walla Walla, Washington, in June 1947, at which many people testified pro or con. The gist of the proponents' arguments for a moratorium was given by Thomas Sandoz, vice-president of the Columbia River Packers Association, who said, "Because one power dam is a good thing is no argument six are better." And a spokesman for the Fishery and Cannery Workers' Union added, "Since 75 percent of the salmon spawning areas [an exaggeration] are already lost, the lower Columbia River should be shielded from additional encroachments. Why spend the taxpayers' money for unwanted power, navigation, and reclamation projects before a fish [enhancement] program is fully developed?"

Speaking against the moratorium was Ira N. Gabrielson, chief of the U.S. Fish and Wildlife Service, who argued that the region needed the dams' power and other benefits. Gabrielson and Sen. Warren Magnuson of Washington, who sent a letter to the hearing, felt that the success of the Bonneville ladders augured well for getting fish over additional high dams. The CBIAC referred the issue to its parent body, the Federal River Basin Commission, which concluded unanimously that it did not favor the moratorium because "additional dams would not result in major loss or extinction of fish life in the streams."

In the June 1947 issue of the *Oregon Business Review*, Paul R. Needham, director of research for the Oregon Fish Commission, wrote:

> Some of the plans of the dam builders, if completed, will completely ruin for all time some of the richest fishery resources of the nation. The principal streams concerned are the Sacramento in California, the Rogue in Oregon, and the Columbia with its principal tributaries in Washington, Oregon, and Idaho. A total of some sixty-nine dam sites are now under study in the Columbia Basin alone. Among them is the McNary Dam [already authorized by Congress for construction across the main Columbia above Bonneville near the mouth of the Umatilla River]. If this is built, it will be the beginning of the end of steelhead and salmon runs in the upper Columbia. Another main-river dam is proposed for con-

David Falconer, Black Star



*On their way upriver to spawn, salmon must negotiate such natural obstacles as waterfalls and such man-made ones as the fish ladders at Bonneville Dam. The combination proves too much for some fish.*

struction at The Dalles near Celilo Falls. But the finishing touch will be the four-dam plan now being recommended by the Army Corps of Engineers for construction on the Snake River to provide slack-water navigation to Lewiston, Idaho. All western fishery biologists with whom I have talked agree that this plan, if followed, will spell the doom of salmon and steelhead migrations up the Snake River as well as up its tributary, the Salmon River in Idaho.

Needham's statements were remarkably prophetic.

In the next three decades the Corps of Engineers' dams went up in fairly rapid succession. On the Columbia: McNary, 100 feet high; The Dalles, 88 feet; John Day, 132 feet. On the Snake: Ice Harbor, 100 feet; Lower Monumental, 93 feet; Little Goose, 100 feet; and Lower Granite, 82 feet. All have Bonneville-type fish ladders. The Corps also built Chief Joseph Dam, below Grand Coulee, without ladders, eliminating another considerable portion of the salmonid habitat.

During the Eisenhower administration the federal government temporarily withdrew its interest in the main stems of the rivers and licensed public utility districts in Washington to build Wanapum, Priest Rapids, Rocky Reach, and Wells dams, all supplied with fish ladders. Idaho Power Company was permitted to construct a trio of dams on the Middle Snake: Hells Canyon, Oxbow, and Brownlee. Only Brownlee had fish-passage facilities, and when they failed, the entire Snake River system above the dam was lost to salmon and steelhead.

All the consequences of damming a mighty river teeming with valuable migratory fishes have occurred on the Columbia. Nowhere in the world have salmon had to cope with so many man-made difficulties; yet with the help of a tremendous hatchery program, some of the runs continue to exist in relatively respectable, if diminishing, numbers. Fish that spawn in the upper reach of the Columbia in Washington, such as the Okanogan River, must hurdle nine dams with accumulated elevations of over 800 feet in a stretch of about 500 miles. At each obstruction they must find the entrances to the ladders, adjust to conditions in the reservoir, and still have enough stamina to reach their destinations and spawn. Fish heading for Snake River tributaries, such as the Salmon and Clearwater, must pass eight dams with a total elevation of almost 800 feet; losses are great betwen dams as the fish die from exhaustion or from bubble disease generated by an excess of nitrogen gas in the reservoirs.

However, by far the greatest mortalities are suffered by the tiny fingerlings. The increasing demand for power has made the Bonneville Power Administration, which markets the electricity generated at all federal dams, and the public utility districts in Washington reluctant to taper off generation of energy in the spring during fingerling migration by allowing some of the water to flow through spillways. When the fingerlings can take this route instead of dashing through the turbines, their chances of survival are much greater. The losses at some dams have been so enormous in recent years—95 percent in the drought year 1977 on the Snake River—that extraordinary measures had to be taken. In 1979 some five million juveniles were collected at Lower Granite and Little Goose dams and transported by trucks (called fish pullmans), barges, and even airplanes for release below Bonneville. Survival rate by this means is said to be more than twice that of juveniles that go through the turbines.

"Extensive effort has been made to improve fish passage ever since Bonneville Dam was built," says William E. Pitney, a biologist with the Oregon Department of Fish and Wildlife.

> The resource management agencies of the several states have struggled with many problems. Improvements have been made, but for each gain an almost unending host of other problems has been recognized. Once it had been determined that adult fish could pass over high dams it was quickly discovered that their young were ineffective in finding their way downstream through many miles of slack water. This resulted largely from the water being impounded at the time of year the migrants should have been carried by the freshets to the sea. Some of those which do leave the reservoirs find only the turbine systems as outlets and are killed by pressure changes of spinning blades.

Thanks to the dams, the Columbia is now completely tamed from tidewater to the headwaters in British Columbia, except for about fifty miles of free-flowing water around the Hanford reservation, site of the greatest concentration of nuclear plants and nuclear-waste dumps in the world. Even here the Corps of Engineers has staked out its claim and despite intense opposition is hoping to build Ben Franklin Dam, for which it has already received planning money from Congress. The deep chasms and canyons, the thundering cascades, the huge rocks over which the river had beat endlessly when spring torrents came down from the mountains have all been drowned out. Most of the birds that used to feed and rest in the sloughs and channels—Canada geese, pelicans, many species of ducks, cormorants, eagles, condors, herons, and cranes—have either vanished or are seen in very small numbers. Deer and elk populations are sparse. There has not been a major flood since 1948.

Along the tidal portion of the river there are towns and cities, factories, mills, tank farms, aluminum smelters, and other industrial establishments.

Around metropolitan Portland the spoils of industry plague the Columbia and foul fishermen's nets. East of Portland, the brooding cliffs and rimrocks are unscarred, but the forests of Douglas fir and associated species have been gashed by huge clearcuts.

Above Bonneville, one dam and its reservoir succeeds another for 450 miles to the Canadian border, and the scene is repeated on the Snake River for several hundred miles. Spidery transmission lines, taking energy from the fifty-four major dams in the basin, connect the steel towers that march across the landscape in every direction and bring electricity to cities and villages, factories, farms, and isolated ranches, at rates that are a fraction of those in the Midwest or the East.

Development of the hydroelectric potential of the rivers has brought immense boons to the Pacific Northwest: low-cost power, a forty-foot navigation channel to Idaho, water to fructify millions of acres of semiarid land, and elimination of floods on the once turbulent Columbia. Offsetting these gains has been the loss of much of the salmon stocks.

Of the four species of salmon in the Columbia, the once abundant chum have totally disappeared, and the equally numerous red salmon have been reduced to token numbers. Coho had almost vanished from the river by 1960, then made a phenomenal comeback thanks to a breakthrough in salmon culture with the development of pellet feed. Now, for reasons biologists can't fathom, coho are again in serious decline all along the Pacific coast. Stocks of spring and summer chinook are at a nadir. Fall chinook is the mainstay of the commercial fishery and, along with coho, of the sport fishery. Winter steelhead runs are in fairly good shape; summer steelhead runs are not. The upriver races have experienced the most serious deterioration because of the difficulties of surmounting the many dams.

About half of all sport and commercial catches are the products of some fifty salmon hatcheries in Oregon, Washington, and Idaho. In the 1970s commercial landings, exclusive of ocean catches, averaged nine to ten million pounds a year, a quarter to a third of what they were fifty years earlier. The increase in ocean catches has not been substantial enough to make up the shortfall, and the canning industry on the Columbia is moribund—only 4,400 cases were packed by the four plants still in operation in 1978.

To retain as much of the anadromous fish stocks as still survive has been costly. More than $500 million has been spent by the federal and nonfederal power entities to construct ladders and other fish-passage facilities at the dams, and for salmon and steelhead hatcheries, research facilities, stream improvement programs, screening of irrigation ditches, and other works. This is by far the most ambitious and costly fish-saving undertaking anywhere in the world.

What of the future?

In 1979 two months were lopped off the ocean-trolling season, gill netting in the river was reduced to 55 days (compared with 272 days in 1938), the sport-fishing season was curtailed by a month, and the bag limit cut to two salmon a day from three last year. Still, too many fishermen were chasing too few fish, and all user groups were unhappy. The 300 to 400 Indians, belonging to four tribes that have a private fishing reserve on the Columbia by virtue of the Walla Walla Treaty of 1855, exacerbated the situation by filing one suit after another in the federal district court at Portland to curtail the white men's fishing season. They fear it would adversely affect their chances of catching 50 percent of the harvestable salmon that enter the river, as allowed by a court ruling.

In Oregon the retail price of salmon has reached $6.00 a pound, higher than the best cuts of beef. As part of a many-pronged effort to produce more fish, biologists say, "Give us more money and we will provide more salmon." On this assumption Congress has funded the building of hatcheries to make up the losses at the Snake and Columbia river dams. If Congress provides the funds, double the volume of fingerlings will be released into the streams, from 75 million to about 150 million annually. Whether these fish will fare better than their predecessors in getting past the dams is not certain. There is, however, plenty of habitat available to accommodate additional adult populations. Terry Holubetz, director of the Pacific Fishery Management Council, says that in Idaho alone there are some 3,500 miles of streams with clear, constant water and undamaged spawning areas.

Another approach to the problem is to persuade the electric power agencies to reduce generation at the dams when fingerlings move seaward in order to allow more of them to go over the spillways. As more powerhouses rise at these projects, however, the fear is that inevitably there will be so much capacity—to satisfy Gargantuan demands for electricity—that at times almost the entire flow of the Columbia will be run through the powerhouse at most projects, unless Congress forces the utilities to reduce generation and allow more fingerlings to pass over the spillways. This is a key provision in the Northwest Energy Bill now going through Congress—and it is being fought bitterly.

Water rights are allocated by the states for different uses but migratory fishes have never been accorded such rights. The Federal Power Commission, which licenses the dams, is sympathetic to the need of curtailing generation to save the fingerlings, and some progress has been made in persuading the Bonneville Power Administration and the public utility districts to reduce generation, a move that aided fingerling survival in 1977, 1978, and 1979. Fishery agencies are also urging the Bureau of Reclamation to reduce water withdrawals at some of its projects for the benefit of salmon migration and are opposing the Bureau's plan for irrigating some 500,000 additional acres with Grand Coulee reservoir water. They say that the region already has too much irrigation for growing sugar beets, potatoes, and dryland wheat, all of which are in excess supply in the United States.

If these and other proposals to ease the salmon crisis are not soon implemented, one cannot help but conclude that the upriver races face additional losses and perhaps, in the not too distant future, will be reduced to token populations. Should that happen, there will be few salmon and steelhead climbing the ladders at the dams, and the stocks will be almost entirely confined to the lower river, testimony to the folly of believing the engineers when they said, "We can have fish and power, too!" ☐

*From platforms over the water, Indians use the traditional dip net method to scoop up salmon. This fishing site is at the Cascade Locks on the Oregon side, upstream from Bonneville Dam.*

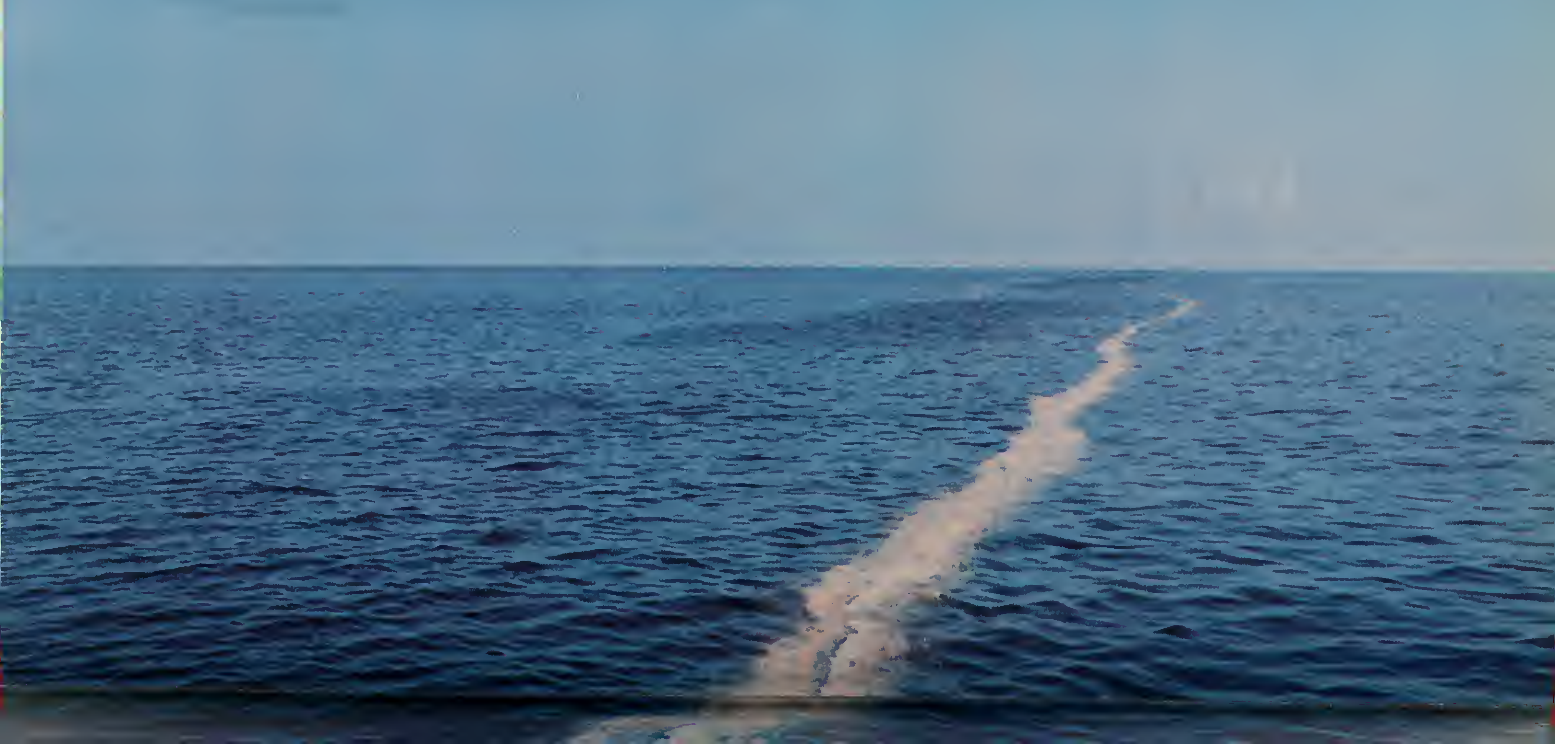
David Falconer, BlaStar

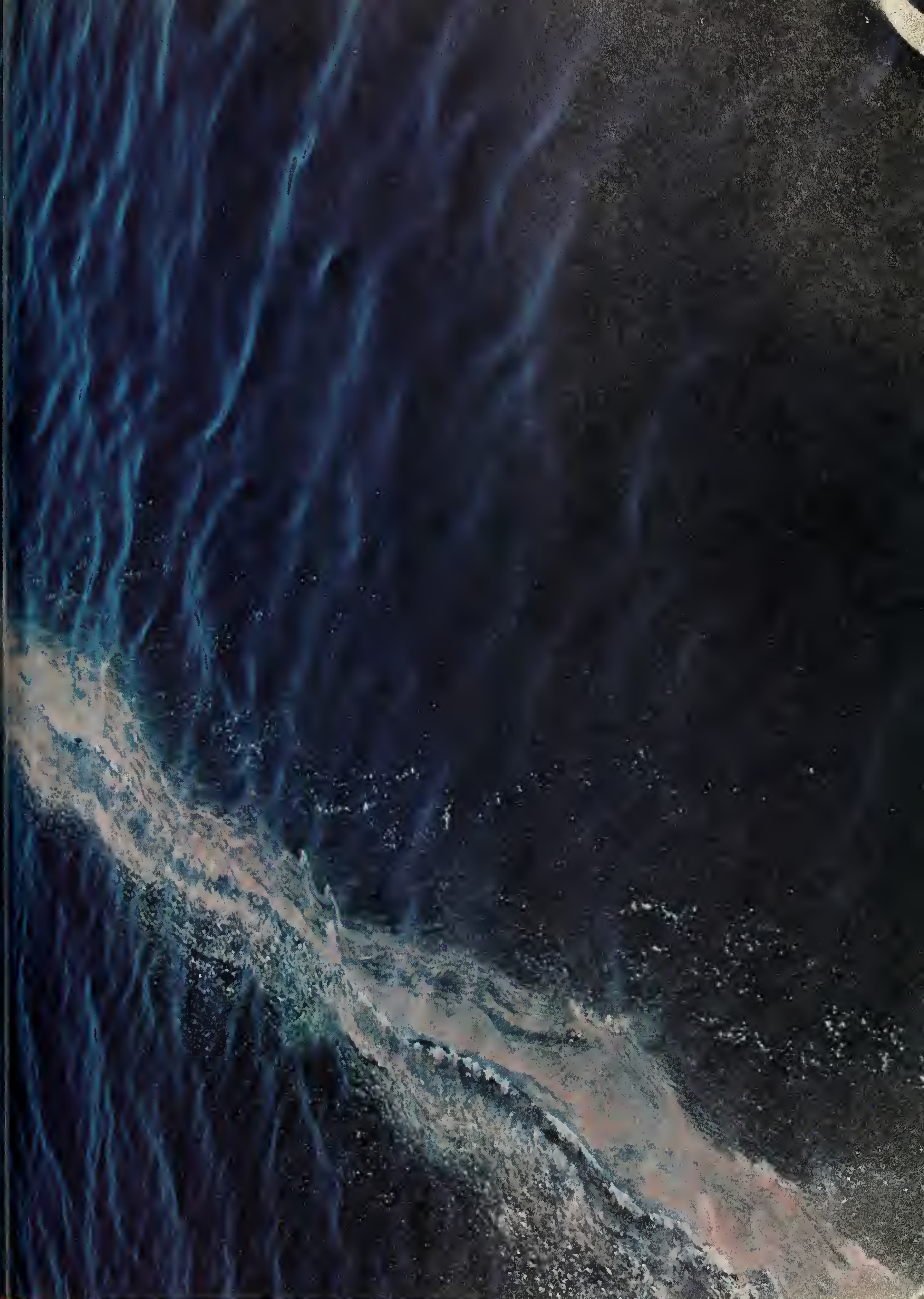
# Pink Stripe on the Ocean

In late August or early September, when there is a spell of calm weather near Bermuda, you can sometimes see one or more pink stripes on the water several miles offshore. They look as if they had been painted from the near to the far horizon with a giant brush. James Burnett-Herkes, director of Fisheries in Bermuda, told me that the pink material is coral spawn, consisting of motile larvae released by anthozoan octocorals, which float to the surface and are swept into a narrow band by down-welling convergence currents. If these larvae were to settle on a reef, they might grow into sea fans, sea feathers, or other soft corals. But the ones in this photograph were probably eaten by fish or crustaceans.

The convergence currents are caused by the evaporation of water in the shallow lagoons of the Bermuda platform during the summer. Warmer water would normally float on top of the colder water from the Sargasso Sea, but because the warm water has evaporated and become more saline, it has also become more dense. Thus, in calm weather in the late summer, shallow water can run slowly and smoothly off the edge of the platform into deep water, creating an amazingly sharp boundary. That boundary, which would otherwise be detected only by someone making a temperature or salinity survey, is made dramatically visible by the presence of the brightly colored coral spawn—the "paint" of this mysterious "highway stripe."

*Photograph and caption by James N. Butler, professor of applied chemistry at Harvard University and a trustee of the Bermuda Biological Station.*





**Editor's Note:** *The pictures accompanying this article have been independently selected by* Natural History *as representative or suggestive of the people and places described in the text. Persons shown in the photographs bear no relation to the characters the author has created for narrative purposes.*

# Afghanistan's Sorrow and Pity

*A rural schoolteacher, educated in the nation's capital, is faced with a clash of loyalties*

**by Ashraf Ghani**

خلق
صنف خبازان

Just as the thick dark of the night was giving way to the pale light of early dawn, the ringing of the alarm clock shook Gulab out of his sleep. He hastily got out of his cot and, after making his ablutions, rushed to the local mosque. With a sigh of relief, he noted that other people were still arriving. He was keenly aware that some people were keeping a close record of his attendance, as well as other of his activities. As he mechanically performed the rituals, his mind wandered over the conflicting demands that were ripping his life apart.

Like everybody else in the mosque of Khost in southeastern Afghanistan, Gulab was born in the vicinity of the town. He was thirty or thirty-one years old. As dates of birth were not recorded, he did not know his exact age, but he knew the tribal lore well. He remembered the times spent with his father, memorizing the names of his seven paternal ancestors as required by custom. His father had made sure that Gulab and his three brothers knew the names of the various lineages and clans that jointly made up the Pashtun ethnic group. They were also told about the groups that were allied together and those that carried on feuds.

When Gulab was a boy, his father owned four acres of irrigated land and about forty watered by rainfall in a village fifteen miles east of Khost. He was also involved in the illegal trade between Khost and towns across the border in Pakistan. The biggest item of trade at the time was wood. Some of the now barren mountains were forested then, and others had a much

*In early September 1979, supporters welcomed home President Taraki from the Nonaligned Nations Summit in Havana. Taraki was deposed on September 16, and some days later his death was reported.*

Rick Smolan, Contact

thicker layer of green. But people had to make a living, and nobody was concerned about the changing nature of the scenery or the erosion that deforestation would precipitate.

In those years, Khost was not a particularly healthy place. It was infested with malaria, and the people preferred their cooler villages on the upper hills to the damp and flat valley in which the town was located. Few people wanted to settle in Khost for long. Yet, a government garrison had been stationed in the town since the mid-nineteenth century, and the governor of Paktia Province spent the winters in the town.

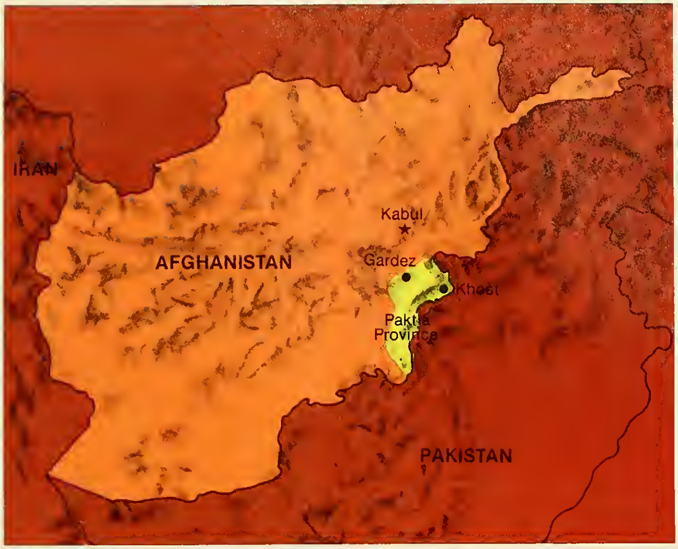
But it had not been Gulab's lot to avoid Khost. He remembered his first trip there well. One day when he was about six years old, he and his brother Sur Gul, who was a year younger, were told to put on their fine clothes and were taken to the town. In those days there were no trucks or buses linking the villages to the town, and the boys were put on a donkey while the older men walked. One of Gulab's two sisters was married to a man whose village was about two miles from Khost, and the brothers were at first told that they would be staying there for some time. In fact, they were to attend the school in Khost for the next six years.

Gulab's father was not literate. He had not allowed his eldest son to go to school and, as it later turned out, was not going to permit the youngest one to enroll either, but his dealings with the governmental machinery had convinced him that it might be useful to send his two middle sons to school. So in 1956 Gulab and Sur Gul found themselves in school.

The two boys were terrified by the discipline. Whenever they felt the need, teachers and headmasters used the stripped branch of an almond tree on the students. Most of the students were much older than the two brothers; some had spent two or three years in the same grade without learning to read or write. As the central government held the headmaster accountable for the number of enrollments per year—public schooling was in theory compulsory—those students unwilling to attend the classes were dragged there by the school's orderlies. A generous bribe to the headmaster was the only way their parents had to release them from their misery.

*In much of the Muslim world, the home compound has separate quarters for women, but this is not typical in Paktia Province, where women have more contact with the outside.*

Joe Le Monnier



After their pleas for returning to the carefree life of the village were rejected, Gulab and Sur Gul accepted the inevitable and passed their exams regularly. Despite their acclimation, they cherished their three-month summer vacations, which they spent in their home village, sharing in the schemes of their age-mates.

Graduation from the elementary school brought about a longer period of exile for the two brothers. Through some connections in Kabul, a member of their lineage learned that the government had established two special high schools for students of the border areas. Unlike other schools in the capital, in the special schools the language of instruction was Pashtu. In addition to room and board, students were granted a monthly stipend. The relative persuaded Gulab's father to enroll Gulab in one of the high schools and to send Sur Gul to a military school, also located in Kabul.

This time, the trip was longer and more strenuous. After tearful partings from their mothers, who entrusted each with a bundle containing clothes, some home-baked cookies, and a cone of refined cane sugar, a band of thirty boys from villages surrounding Khost headed toward Gardez, the provincial capital. Steered by five elders from different clans, the group took three days to walk the one hundred or so miles separating the two towns. They spent the nights in mosques or guesthouses of the various clans along the way. It rained on the last day of their trip, and when they reached Gardez not only were they soaked but the sugar in their sacks had melted, permeating all their clothes with a special smell. The owners of teahouses, which also served as guesthouses, refused to receive them at first until one of the elders accompanying them found a local friend who intervened on their behalf.

Gardez was much larger than Khost; its size and the number of soldiers pacing its streets awed the boys. They listened with fear as some shopkeepers described the methods of torture that the governor administered to those who dared defy his orders. However, the sight of the trucks on which they were to be taken to Kabul overjoyed them. The trucks were loaded with wood on which they had to sit, but this was the first time most of them were riding a vehicle, and they were thrilled at the prospect and pleased not to be walking. They sang Pashtu martial and love poetry and were amazed at the speed of their journey. The trucks were making about ten to fifteen miles an hour!

*Roads are the transportation backbone of Afghanistan, which lacks railroads and navigable rivers. Despite some upgrading of the highway system, travel conditions often remain as rugged as the land.*

Covered with dust from the dirt road, they reached Kabul after about ten hours' travel. Henceforth, Gulab's and Sur Gul's lives were to be intertwined with the rapid tempo of political change in the capital. Nobody had any inkling of what the future held in store, of course, and when he was taken to his room in the school and shown his bed, all that a tired Gulab desired was blissful sleep. The night was quiet, but with dawn the new adjustments began.

Life in school resembled that in a military barracks, and there were elaborate rules for what could and what could not be done. The rest of the city remained a great mystery to Gulab and his fellow students. On holidays and Fridays they walked around the town and even, at times, managed to see a movie, but they never made any real contact with the local people. Gulab slowly mastered the Persian language, but the opportunity to use it was basically confined to the classroom and his weekly rounds in the markets of Kabul. Gulab spent six years in the school, yet not once did he have a meal in a house. The only house he visited was that of the principal, but not for social purposes. The principal was building two new houses for himself, and to avoid hiring labor, he assigned teams of students to work on the site.

Eve Arnold, Magnum

In these years, Gulab's perception of Afghanistan underwent radical changes. Textbooks told him of an indestructible country that had managed to resist all attempts at annexation and conquest for some three thousand years. While he readily imbibed this part of the nationalist credo, he was more ambivalent about the portrayal of rural revolts. The textbooks painted an image of a progressive central government whose designs were destroyed by the bigotry of the rural people. Not far from his school was a monument, called the Minaret of Knowledge and Ignorance, which

celebrated the victory of the reforming government over the rebels of Khost in 1924. But Gulab had heard a different story in Khost. The elders of the village had told him that they had been resisting a despotic government's interference in their customs and its demands for revenue. At home Gulab himself had repeatedly sung some of the antigovernment poetry of the period. To say the least, he was confused by the discordance of the two versions.

During their three-month summer vacations, Gulab and his brother went back to their village near Khost. Transportation now reached the town, and the boys rode on the back of trucks. They were becoming adolescents, and there was talk of looking for suitable matches for them. As the last year of high school approached, the boys' family arranged their engagements to two girls from nearby villages. Since they had never seen the girls before, they spent long hours wondering what they looked like. Custom allowed the future mothers-in-law to arrange for the couples to meet without the knowledge of their hus-

Frank Ward

*Men relax and confer in a teahouse in Paktia Province. Pashtuns, who make up more than half of Afghanistan's population, include tribes of sedentary agriculturists and nomadic herdsmen.*

Roland and Sabrina Michaud

bands, who played the role of stern patriarchs. Gulab and Sur Gul were finally permitted to see their future wives in the presence of their mothers, but nobody quite knew what to say, and they just stole glances at each other. By that time, vacation was over, and the boys had to return to school.

Life in school was suddenly transformed. A series of high school student unrests and widespread political agitation at Kabul University had erupted following Gen. Mohammad Daud's ouster as prime minister, a post he had held for about a decade. The movement had taken five years to reach Gulab's school, which was finally in the throes of overdue change.

Food in the school had always been bad. It was common knowledge among the students that part of the funds assigned to their upkeep was diverted to pay for the principal's new houses. Nobody had dared to complain, taking for granted that all government bureaucrats were corrupt. On hearing that the Ministry of Education had considered similar complaints from the students of Kabul University, some of Gulab's classmates decided to follow their example. They even convinced a number of students, including Gulab, to accompany them to the university to see for themselves.

This was Gulab's first visit to the university. He was amazed to see so many extremely well-dressed girls and boys and, at first, took them to be part of the staff, only to learn they were all students. A number had their own cars and others used chauffeur-driven governmental cars. When he expressed his surprise at this wealth, a friend commented that these students came from a class other than that to which people like Gulab and himself belonged. Seeing the expression of bewilderment on Gulab's face, the friend explained that the word "class" expressed the difference in wealth and social standing of different segments of society.

Gulab knew that in his village there were people called *mala*, which meant "filled with food," and those called *wigi*, which meant "hungry." He knew that the size of landholdings in Khost were unequal. But a considerable part of the land of one person, if not all of it, would not be enough to pay for one of the cars the students were driving. A thought suddenly flashed through his mind: If the sons displayed so much wealth, how wealthy must the fathers be!

The sight of the university made such an impression on Gulab that he could not absorb the advice he and the other students were given on how to voice their discontent. The idea of bringing their complaints to the Ministry of Education, however, was circulated among his fellow students, and although most were frightened, they all agreed that the situation was intolerable. A few days later, some students challenged the authority of the principal by refusing to eat their supper. Infuriated, the principal reacted by trying to beat one of them. Others came to his rescue, and a melee broke out between students and orderlies. Some teachers intervened, and soon a representative of the Ministry of Education arrived at the scene of the fight. After inquiries, which took almost a month, the school got a new principal, the food improved, and there was no more talk of working on housing sites in the evening.

Soon it was time to prepare for the entrance exam to the university. Only by accident did the students, who were familiar only with writing essay examinations by rote, learn that it was to be of the multiple-choice type. A

friend from the university volunteered to explain what this meant and even gave them a trial exam. When the examiners came from the university, they took only a couple of minutes to explain the procedure before administering the exam.

After some six months of anxious waiting, Gulab learned that he had been admitted to the School of Natural Sciences. He was granted a place in the dormitory, where he was to share a room with five other people, none of whom was from the vicinity of Khost. Two were Pashtu speakers, but the other three spoke hardly a word of it. Also, all professors lectured in Persian. Gulab made a strong effort to understand what was said in class, but he was acutely aware that the students from Kabul made fun of his accent. Not wishing to risk ridicule, he grew reticent in class and would not take part in discussions.

Life in the dormitory was different. Gulab thought it funny that he was becoming closer to his Persian-speaking roommates than to the Pashtu-speaking ones. These last two came from major land-owning families, and everybody was soon aware that they had used forged documents on their family income in order to qualify for the subsidies provided by the university. They carried sufficient cash to go regularly to restaurants and movies. When in a good mood, they even spoke of their exploits with women and told Gulab that they made regular visits to prostitutes. Gulab, who had never been told that one could have access to a woman outside the bounds of marriage, now realized there were many things he did not know and braced himself for future surprises.

Gulab's three Persian-speaking roommates came from a background similar to his own. One from the valley of Darwaz, in the province of Badakhshan, told Gulab that his village was right on the bank of the Oxus River, which bordered the Soviet Union. Gulab was amazed to learn that there

*Lumber is loaded for local use. Despite a harsh climate and terrain, Afghanistan has some luxuriant forests. Many have been depleted, however, by large-scale timber smuggling to neighboring Pakistan.*

Ralph Gates

was a large town on the Soviet side of the border and that it had an airport where some fifteen to twenty planes landed every day. Gulab had been to the airport of Kabul only once, but the description of the Soviet airport convinced him that it was much larger than the Kabul airport. And, he marveled, the airport of the Soviet capital must be even larger than that of a provincial town.

He also learned that people in Badakhshan spoke several languages and that Persian was not, in fact, his friend's mother tongue. It was the same with another of his roommates, who came from a small village in the province of Balkh, in northern Afghanistan, and whose mother tongue was Uzbecki. Only the third roommate, who came from Hazarajat in central Afghanistan, was a native Persian speaker, but even his accent was not like that of Kabul. Although the boys at first hesitated to trust each other, they gradually found that they had a lot in common. Other differences, however, came to the fore.

All were aware that there were students who were members of various political parties, and Gulab had even heard some of them deliver speeches on oppression and class struggle in a corner of the campus where a forum was regularly held. Toward the end of the first semester, one of these boys, who lived in the next room, approached Gulab and asked whether he would be interested in reading some of their literature. Gulab said he would not mind, and the student gave him three novels written in Pashtu by Noor Mohammad Taraki, who was to become president of Afghanistan some ten years later, after the coup of April 1978.

These books centered on the description of life in rural Afghanistan and of migrant Afghan labor in British colonial India. Religious dignitaries were condemned as parasites, and the consumption orientation of the rural and urban upper classes was deplored. But the books also had a positive message. In each one, the chief character was made to declare that if the working people united, they could put an end to this condition of inequality and abolish the whole stratification of society.

Gulab was favorably impressed and asked his contact for more material. Meanwhile he discussed the books with his three roommates. To Gulab's surprise, one of the boys told him that although the author claimed to be a socialist, he was in fact a Pashtun chauvinist and that most of his followers were Pashtuns. The second said that he could not possibly agree with an atheistic author, and that Islam, although abused like any other religion, was capable of being generated from within. True equality, he said, had only existed during the reign of the first four caliphs. The third one disagreed with all of them, declaring that the Soviet Union, which had inspired the author in advocating a method of peaceful struggle, was no longer revolutionary. He maintained that the only revolutionary country in the world was the People's Republic of China; that the only true harbinger of the future was the Maoist group in Afghanistan. Taken aback, Gulab did not know how to respond. When his three friends realized that he had not, in fact, joined the party of Taraki, they each urged upon him their own literature and implored him to meet with their comrades, who would explain their course of conduct to him in detail. Although Gulab agreed to take a look at their material, he had to prepare for his examinations and did not get around to reading it until

Ralph Gates

*Kabul, Afghanistan's capital, is the center of economic and cultural activity. Above, a donkey caravan passes through a bazaar. Right, the Intercontinental Hotel overlooks a modern quarter of the city.*

the next year. But the discussion in the room continued, and while Gulab listened, each of the three boys stuck to his position and attacked that of the others.

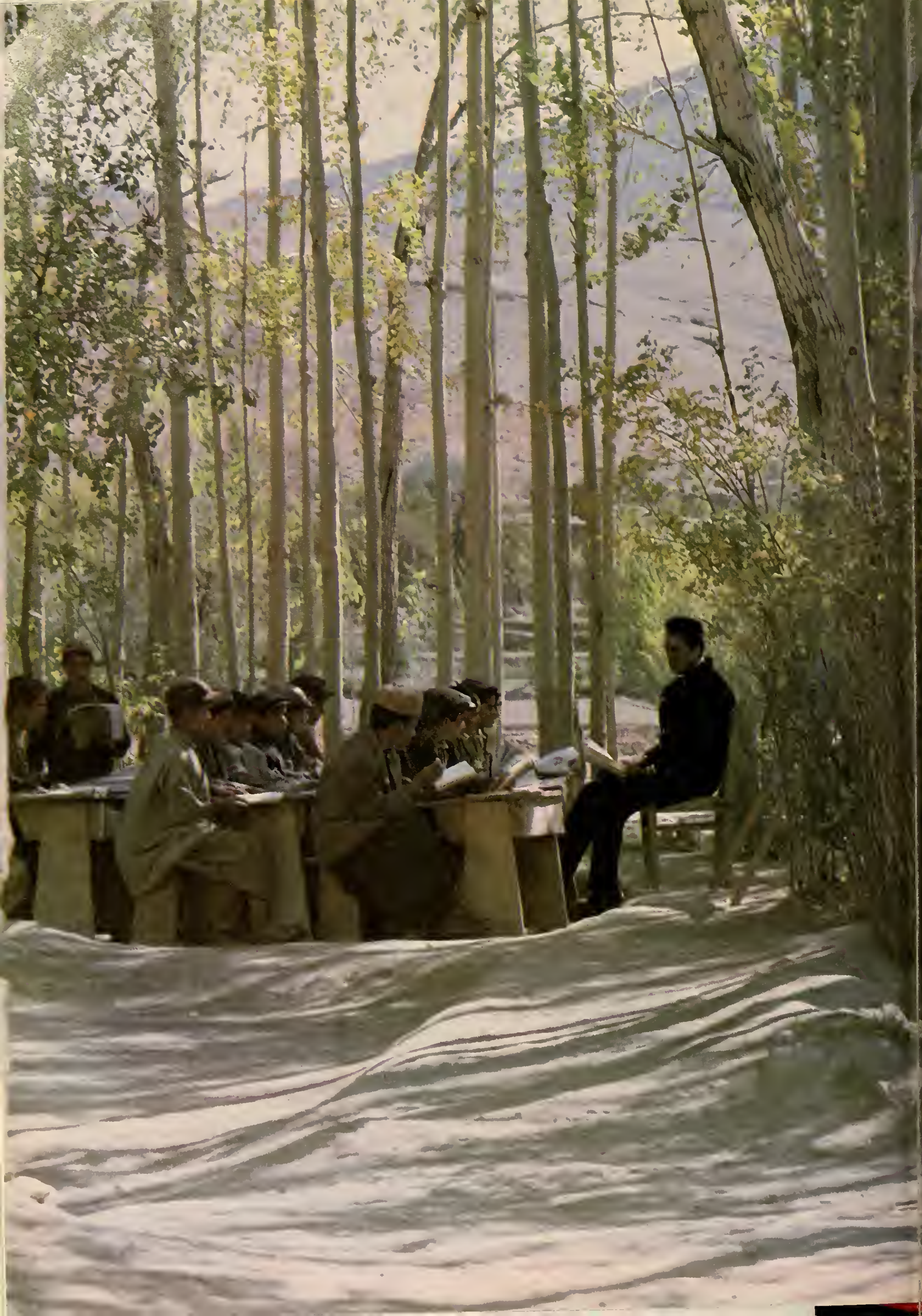
One day, just before the beginning of the summer vacation, Gulab's brother Sur Gul, who was attending the military academy and whom Gulab now saw only occasionally, came to his room in great excitement. He had been granted a scholarship to pursue his studies in the Soviet Union and would be leaving in six months. Training was provided by the USSR, the only country offering military aid to Afghanistan. The brothers rushed to the bus station—by now buses were running to Khost—and told a relative who was a bus driver to inform the family of Sur Gul's good fortune. A week later Gulab and Sur Gul left for home.

The family had changed during their absence. Gulab's father and elder brother were now involved in smuggling Pakistani cloth to different provinces in Afghanistan and in taking wood from Paktia Province into Pakistan. The father was also negotiating about becoming the agent of a company that imported spare parts for trucks to be smuggled into Pakistan. The family, with a group of friends, had bought some camels for transporting the goods across the border. They had also invested in a minitruck, and Gulab's youngest brother, who had not been sent to school, was transporting people and goods between Khost and the surrounding villages. The family members were wearing better clothes and eating more meat and rice than during Gulab's childhood.

Upon the boys' arrival, the topic of conversation became Sur Gul's impending departure and the responsibilities of the family. Although everybody had heard that the Soviet Union was an atheistic country, the father and elder brother were not particularly worried by this and were happy that Sur Gul had been granted the scholarship. An officer who was related to a business associate had told Gulab's father that recipients of these scholarships advanced very rapidly in their careers and were bound to be entrusted with important governmental posts. Obviously, all the family would gain from his influence.

The discussion turned to the mar-

Luis Villota



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riage of the two boys. As Gulab was older, he was expected to marry first. The plans had been that Gulab's marriage would take place in a year and Sur Gul's in three years. But Sur Gul's imminent departure changed the whole picture. The family could not meet the expense of two marriages on such short notice and yet did not know how to avoid hurting Gulab's feelings and violating the custom. Sensing the dilemma, Gulab came forward and said there was no need for him to marry at the moment; that he would go and explain the problem to his future in-laws. The father and the elder brother agreed and advised Gulab that when he paid his visit, he should take a sheep and some special presents. Without asking Sur Gul, it was decided that his wedding would take place in a month.

On the eve of the occasion, Gulab's father, his four sons, and some of the elders of the village drove to the bride's village and gave her father the last installment of the bride-price. Half of the money had already been given at the time of the engagement. The total sum amounted to fifty thousand afghanis—the price of one acre of irrigated land—and the family spent another ten thousand on the marriage ceremony itself. The teen-age bride was brought to Sur Gul's village, and during his five years in the Soviet Union, she stayed with his family.

Meanwhile, Gulab gained the confidence of his future mother-in-law, and several times she allowed him to visit his fiancée alone. Gulab found her quite pleasant and was fairly happy with what fate had brought him. He was so busy during all these months that he completely forgot about the literature that his roommates had given him. He saw the books again as he was preparing his bag just before leaving for Kabul.

The political climate of Kabul was as intense as ever, and Gulab soon found himself in the midst of conflicting demands. There were frequent demonstrations, speeches every day in the special corner of the campus, and intense discussions in the dormitory on the merits and shortcomings of various parties. Professors took sides more or less openly and actively tried to build a loyal following among the students. There were allegations that grades reflected the political beliefs of the students more than their competence. There were also rumors that some of the professors took bribes, and that most of the rich students were passing without studying. There was even talk that some members of the faculty took advantage of female students. Everybody was full of accusations, and Gulab did not know whom to believe.

As he slowly read over the material that he was given, one question increasingly bothered him. What did all this have to do with Afghanistan? He read the Chinese attacks on the Soviet Union and those of the latter on the former. He read fragments of a piece on how out of ten hours of work the workers were given wages for only five, but there were very few industrial workers in the country. Even the literature of the Muslim group dealt with Syria and Egypt. Gulab spent most of the year considering the merits of the pieces he was reading and preparing for his exam.

From time to time, his father and two brothers from the village would visit him on their way to other provinces in Afghanistan. The father even spoke of buying some land in northern Afghanistan. Gulab's involvement in the family economy was minimal; he was never asked his opinion and kept his thoughts to himself. But even in his own mind he did not know how to react to the relative expansion of his family's resources.

When Gulab returned for his vacation, plans for his wedding were under way and he was married. By the time he left, his wife was expecting a baby. Gulab, of course, had no income of his own, and all the expenses of his wedding and the maintenance of his wife were paid by the family. He took advantage of every major holiday to visit home, but as the trip took two days each way, he could not make it as often as he wished.

By Gulab's third year of studies, things at the university were in turmoil. Demands for establishing a student council led to a full-scale student strike, and the government stopped supplying food to the dorms and asked the students to leave. Although the university was officially closed for some time, committees of students and faculty met regularly and became even firmer in their demands. Students raised funds from inside the country, and even Afghan students from abroad sent money to provide food for the university. It was during this strike that Gulab became known as a sympathizer of Taraki, although he had not officially joined his party. One day he was taken to Taraki's house, which was located only a couple of miles from the campus. Taraki was a plump man with a cleanshaven head. In his humble manner, he told the group that their demands were legitimate and that history would prove them right.

Gulab was becoming fairly active in the strike when he received a message that his father was seriously ill. He reached home just in time to witness his father's last words, asking his sons to remain united. With the death of his father, the authority in the house passed over to the elder brother. Since harvesttime was approaching and the family had been deprived of an active member, the elder brother asked Gulab to oversee the management of the house. Gulab stayed the summer until the university reopened. During this time his wife gave birth, and he was the father of a son.

Back for his final year at the university, he continued his political activity, which now included trying to recruit others to his beliefs. He was told by members of Taraki's party to make use of his knowledge of local conditions to attract the sympathies of students from the region of Khost. Although some joined, others were quitting. The membership of the various groups was not stable, and there was much crossing over. Gulab himself did not feel particularly bound and still did not join Taraki's party officially. There were more strikes, more protests. All of the city was gripped by the debates in parliament on the question of languages. A proposal for turning Pashtu into an official language was being considered, but for months the quorum was not met. There was also pending a treaty with Iran on the division of the waters of the Helmand River, which had become an issue in the whole country and was portrayed as an act of national

*Because many rural areas lack facilities, classes are often held outdoors. Although compulsory, primary education actually reaches only a small fraction of the population. Fewer girls than boys attend classes, which usually are segregated by sex. The national literacy rate has been estimated to be between 5 and 13 percent.*

Eve Arnold, Magnum

treason by all the opposition parties. Just as Gulab was preparing for his final examinations in the university came the coup of 1973.

Gen. Mohammad Daud, cousin and brother-in-law of the king, and prime minister from 1953 to 1962, overthrew the monarchy and declared the Republic. A large number of the posts in the cabinet were given to junior officers, who according to rumors were sympathetic to the parties on the Left. Yet, open political life in the country came to an end, although it continued underground.

Gulab received his B.A. in chemistry and was assigned to teach high school in the valley of Aryoub in Paktia Province. Aryoub was not very far from Khost, but as it was not on the road between Kabul and Khost, Gulab had never been there. As he rode on the back of a truck toward Aryoub, he was amazed by the beauty of the forest that unrolled in front of his eyes. Unlike the semibarren valleys that surrounded Khost, the mountains were all densely covered with trees. To his dismay, he learned that even from here the wood was increasingly taken to Pakistan. The only government-owned forest was located near the border, and only there did some reforestation take place.

Gulab did not expect the school where he was to teach to be built like the one in Kabul, but he was not prepared for what he saw. The high school, serving about six hundred students, was an old mud house, and most of the classes were held in the open air. Whenever it rained, classes had to be canceled. Next to the school was an unfinished two-story concrete structure; Gulab was told that this was to be the new school, but that contractors and government officials had stolen from the allotted budget leaving it uncompleted. The minister of public works of the new regime had come to the valley, but despite the petition he was presented with by the teachers, the only outcome of his visit was a report in the national newspapers stating that he had been satisfied with the 95 percent completion of the work.

Although all of Gulab's teaching of chemistry was confined to illustrations on the blackboard, he found the students attentive. Only he and the principal, who had a B.A. in literature, were graduates of the university. The other ten teachers had anywhere from six years of schooling to specialized training in teachers' institutes. Despite the seeming geographical isolation of the place, currents of ideas from the rest of the country were very much present. Students quickly started asking Gulab about the political movements in Kabul, and he found out that the teachers had very definite commitments.

Whereas students and teachers were divided along lines similar to those found in Kabul, there were also movements among the peasantry aimed at the revitalization of Islam. A number of theology students, trained in schools in Pakistan, were coming back and trying to teach the peasants what "true" Islam was all about. Gulab also heard of the emergence in a neighboring valley of a soldier as a holy figure; in six months the man had a major following. When the more orthodox mullahs challenged him to a debate, his lack of knowledge of Islamic sources was exposed and he was forced to leave.

While in Aryoub, Gulab sent the major part of his salary home. His wife and child were not with him, and he found his assignment cumbersome. Two years went by. Finally, through some friends and relatives, he secured a contact in the Ministry of Education and managed to be transferred to Khost.

The town had changed considerably. There was a German-operated hospital, as well as a center for reforestation. Shops built of concrete were replacing the old mud structures, and buses and taxis left almost every hour for Kabul. Half of the road to Kabul had been paved; this section could be traversed in about two hours, while the unpaved portion required from four to five hours. Students and teachers were politically active, and the deputy-governor, who had had no formal education himself, kept a wary eye on their activities.

Gulab's elder brother had visited Mecca and was now known as Haji. He had expanded his operations and had even bought a house in Khost where all the male members of the family stayed when they had to remain in town. The youngest brother had also married. Sur Gul was back in Afghanistan and had a post in the armored division in Kabul, but he did not have a house of his own in the city and his wife had to stay with the rest of the family in the village. Every other week he went to see her and his daughter. Gulab too had a daughter now. Although Sur Gul did not share his thoughts with the other members of the family, he confided to Gulab that he had secretly joined Taraki's party and that conditions in the country were coming to a head-on collision. Dissatisfaction with Daud was growing because officers in the regime were being fired, and the regime was drawing closer to Iran.

When one day in April 1978 Gulab heard on the radio that, as a result of their demonstrations in Kabul, Taraki and some other members of the party were arrested, his thoughts went to the safety of his brother. Two days later, however, Daud was killed while resisting a coup, and Taraki became president, prime minister, and chairman of the revolutionary council. Two of Gulab's professors were appointed to the cabinet, as well as some friends of Sur Gul from the armored division. Gulab soon learned that Sur Gul, having played an important role in the coup, had been appointed garrison commander fulfilling the duties of a general. Because Sur Gul was now too busy to leave Kabul, he asked that his wife and daughter be sent to join him. He had been given an apartment and could provide for them. When Gulab took Sur Gul's family to Kabul, he was asked to join Taraki's party and was told that, if he wished, his transfer to another ministry in Kabul could be easily arranged. He answered that he would join the party but preferred to stay in Khost for a while.

Most of the people in the country were stunned by the takeover by Taraki's party and could not really believe it. Many were happy that the old regime had come to an end, and people in Khost were pleased that Taraki was giving his official speeches in Pashtu. Neither the king nor Daud had ever done so, although ethnically they were Pashtuns.

But after some months, disturbing news started to emanate from Kabul. There were rumors of mass arrests and torture of people whom Gulab had gotten to know in his years at the university. There were also rumors that Russians were in charge and that, in response to local armed resistance, the government had dropped bombs on villages in the province of Jalalabad. Parties of people arrived from Kabul and crossed the border to Pakistan. Soon, a number of them were crossing back into the Khost region, openly declaring that they were going to fight the government. Religious dignitaries asserted that religion was in danger, and landlords and moneylenders said that the state was going to confiscate all the belongings of the wealthy. Everybody was taking sides, and people seemed hesitant to speak in front of Gulab.

Government officials said that they were not afraid of any party and that whoever opposed them was reactionary and would be punished. They soon showed that they were not talking lightly. One day, people who came from the Aryoub valley brought the news that planes had bombed the neighboring valley. One after the other, reports of bombing came from every corner of the country, including almost every valley of Paktia Province. Business came to a standstill, and few dared go to Kabul.

In the midst of all this uncertainty, Sur Gul sent his family back to the village. He wrote that he could not live with an ignorant rural wife and was going to marry a member of the party from Kabul. This news made Haji and Gulab's youngest brother so furious that they disowned Sur Gul. Haji also announced that he was going to join the opposition and cross the border; the youngest brother said he was going with him.

Gulab, by this time, was under considerable pressure and did not know what to make of the situation. On the one hand he was witnessing considerable suffering; on the other, the radio was every day proclaiming the glories of the revolution and its achievements for the toiling people. But then came another piece of news. Taraki had been removed from office and replaced by his deputy, Hafizullah Amin. Some weeks later, Taraki's death was announced. Then came news of a huge attack by some four hundred tanks on the town of Gardez, a display of muscle by the central government intended to intimidate the rebels. Khost, by that time, was more or less isolated and few dared move out of it. Gulab was still teaching in the high school, but the number of students was decreasing. Whereas previously nobody had ever asked him whether he prayed, now he had to attend the local mosque and pray with the congregation. The people who showed concern were not strangers; they were his in-laws and kinsmen who told him openly that unless he sided with them, they could not guarantee his safety.

Thus, all his life unrolled in front of his eyes in the early chill of a December morning in the mosque of Khost. Gulab realized that he had to make a decision soon. He could join his brother in the capital by becoming a member of the bureaucracy and embracing the ideology of the emerging regime, but he would have to sacrifice his ties to the community where he was born. Or he could ally himself with his other two brothers in rebelling against the central government; in so doing, he would affirm traditional family ties at the risk of becoming an émigré in Pakistan, severed from his homeland. Neither route could promise safety and security, for the future was too uncertain.

Just as the prayer ended, a soldier came running in, shouting that the Russians had taken over the capital and that President Amin had been shot. There was sudden silence, then a great flurry of noise and activity. Gulab knew that there was no more opportunity for postponement. All his life he had been hesitant about making clear-cut decisions; now he could no longer delay. Either choice was going to be painful.

The sounds in the mosque slowly merged and there was a cry of *Allah u-Akbar*—"God is great." Yet as he looked out of the window, Gulab could see the red flag of the regime unfurling with the wind on top of the government building.

*Gulab is one of some thirty thousand teachers in Afghanistan. In a country where the majority of the people are illiterate, teachers have a very important role to play in implementing the social policies of the new regime. Most of the membership of the leftist parties also comes from the ranks of the teachers. All are confronted with more or less the same choice. How they decide will have a significant bearing on the future of the country.*

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ERRATUM. We regret that two lines were dropped from page 85 of the May book review by Peter Farb. The complete sentence, which begins on page 84, should read: "Their travels began in Mill Grove, Pennsylvania, where Audubon had arrived in 1803, age eighteen, the illegitimate son of a French merchant-slave trader who sent Jean Jacques to the United States to escape conscription into the French army."

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# Celestial Events

### by Thomas D. Nicholson

**The Moon** Phases in July and the first half of August are: last-quarter on July 5 and August 3, new moon on July 12 and August 10, first-quarter on July 20, and full moon on July 27. The moon is an evening object from about July 15 through full moon on the 27th and then appears in the morning sky until early August. About August 13, it reappears as an evening crescent. Perigee moon (nearest the earth) is on July 4 and 30; apogee (farthest) is on July 18 and August 15.

**Stars and Planets** Venus, the spectacular evening star of the spring, becomes equally prominent as a morning star this month. Up with the dawn, it is bright and high in the east each morning until daylight fades it. Mars, Jupiter, and Saturn are still putting on a fair show in the evening sky. All three are low in the southwest at dusk, Jupiter lowest and brightest, near the star Regulus. To the left and higher, Saturn first and then Mars are about as bright as Regulus. The three planets appear progressively lower each night through July. The sun moves from the constellation Gemini into Cancer in July and into Leo in early August.

July 5: Earth is at aphelion, farthest from the sun this year, 152,100,000 kilometers (94,500,000 miles) away.

July 6: Venus, now a bright morning star rising in the east before dawn, ends its retrograde movement.

July 9: At dawn this morning, the waning crescent moon is between Aldebaran, to its right, and Venus, to its left. Shortly after 1:30 P.M., EST (you must adjust for your time zone and for daylight-saving time), the moon covers Venus.

July 11: Mercury, in inferior conjunction, becomes a morning star.

July 15: The young crescent moon is between Regulus and Jupiter tonight. Jupiter, the brighter, to the moon's left, is occulted by the moon at about 10:30 P.M., EST, while it is still above the horizon on the West Coast.

July 16: Tonight the moon is between Jupiter (to its right) and Saturn (to its left).

July 17: The moon has now moved between Saturn (to its right) and Mars (to its left).

July 21: Venus is at greatest brilliancy as a morning star.

July 22: Mercury resumes its direct (easterly) motion.

July 27: A penumbral lunar eclipse (causing only a slight darkening of the full moon) occurs before moonrise in North America.

July 28: The Delta Aquarid meteor shower (about 20 per hour) is at maximum this morning. Look from 1:00 A.M. on.

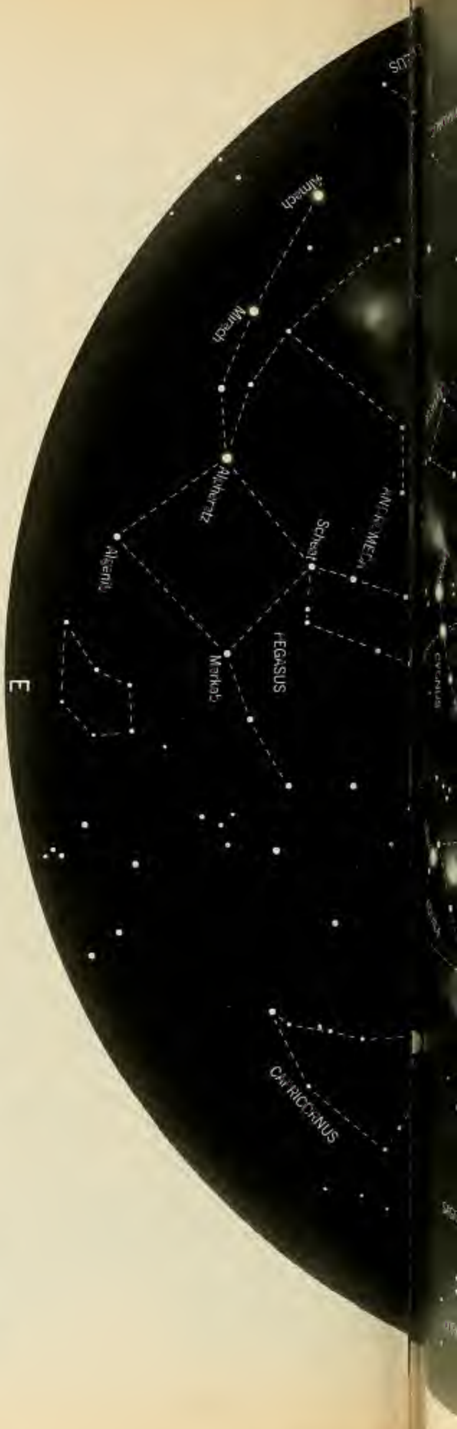
August 6–7: Look for Venus and the moon on both mornings.

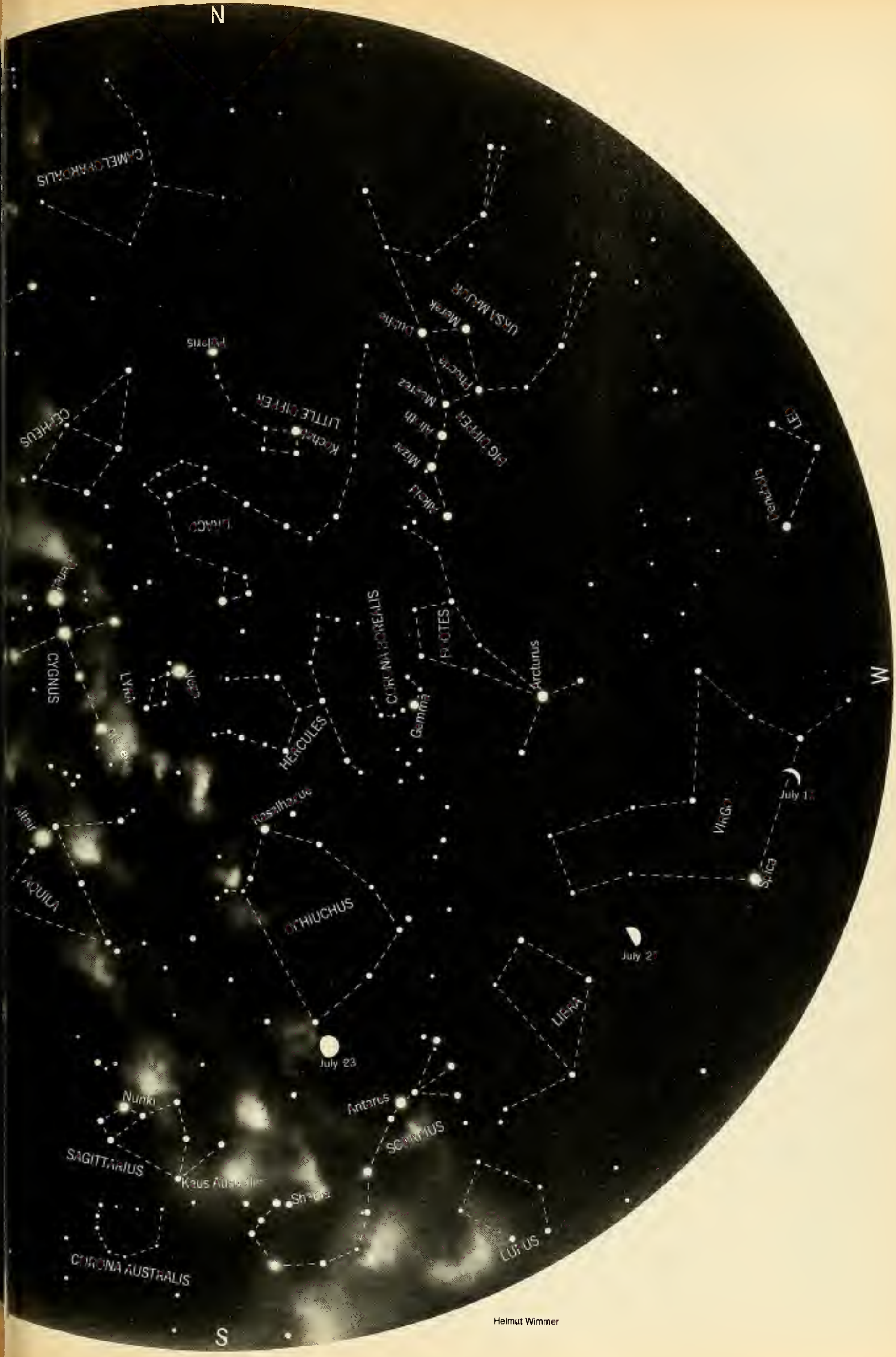
August 10: Today's solar eclipse is annular in a path crossing central South America, partial through all South and Central America, southern Florida, southern and southwestern United States, and Hawaii.

August 10–13: These are the best mornings (from 1:00 A.M. on each day) for viewing the Perseid meteor shower, the most reliable, most productive, and easiest to observe of the year.

August 12–15: The moon passes Jupiter, Saturn, and Mars again. Look for it near the planets in the southwest early in the evening.

**Evening Star Map** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those you see in the sky. When you turn to face in other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match stars in the sky with those on the lower half of the map. The map represents the evening sky from about 11 to 12 P.M. on July 1; 10 to 11 P.M. on July 15; 9 to 10 P.M. on July 31; and 8 to 9 P.M. on August 15. Only planets and moon phases above the horizon are shown and all times are EST.

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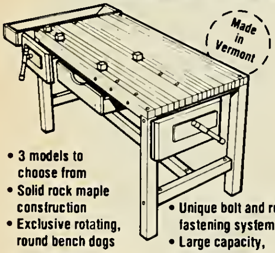

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# A Captive of Birds

### by Michael Harwood

BIRD STUDENT, by George Miksch Sutton. *University of Texas Press, $15.95; 240 pp., illus.*

I have to admit I'm prejudiced in favor of bird painters. From all the available evidence, their craft is exceedingly difficult to master. Having neither the temperament nor the talent myself, I find what they do nothing short of magic. So I am more than mildly interested when one of them writes about his adventures and what he thinks about life, tells how he got started and how he works.

There are not many bird artists, however, who write prolifically and well. To be sure, Alexander Wilson was a poet who taught himself to draw birds, Aububon overflowed with words, and Roger Tory Peterson has a pleasing narrative style. Such people are few and far between. And George Miksch Sutton is especially remarkable— an academic ornithologist and bird artist who writes lucid, literate scientific papers and is at his best a fine storyteller.

*Bird Student* is a summing-up of the first thirty-seven years of a life that has by now stretched eighty-two years. It began in Bethany, Nebraska, where George Sutton was born, the first child of an itinerant college teacher and his musician wife. Eventually, there were also three younger sisters, one of whom died in childhood. The family had a hard go of it financially. Father couldn't always find teaching work, so he was now and then a substitute preacher and, for a while, a worker in a rubber factory. He had a romantic streak—wrote drama, declaimed Shakespeare and poetry—and he was public-spirited: once he even ran for governor of Nebraska on the Prohibition ticket. Mother gave piano lessons and conducted choruses. The Suttons moved to Minnesota, back to Nebraska, then to Oregon, Illinois, Texas, and West Virginia—all before George Sutton was nineteen.

In keeping with that itinerary, his education was helter-skelter, and he began college classes without receiving a high-school degree. For objecting to the wartime "militarization" of Bethany College—everyone wearing uniforms, lots of close-order drills—he was dismissed in the autumn of 1918, his senior year, and didn't finish his degree work until 1923. By then he was a professional ornithologist, working at the Carnegie Museum of Natural History in Pittsburgh. He had already been on his first museum expedition to Labrador and had been asked to provide the color plates for Thomas D. Burleigh's *Georgia Birds* and for Harold H. Bailey's *Birds of Florida*. In 1923 he went to James Bay and the following year to southern Florida on two more collecting expeditions for the Carnegie Museum.

At twenty-six, Sutton became Pennsylvania State Ornithologist and chief of the Bureau of Research and Information of the Pennsylvania Board of Game Commissioners. (The salary allowed him to carry out a long-standing plan: he bought his parents a permanent home.) The game commissioners loaned him to Carnegie Museum for an expedition one summer, and he went off to the east shore of Hudson

Bay. While there, he decided to quit his job in Pennsylvania and take his Ph.D. in ornithology at Cornell University. Gathering material for the doctorate, he spent a year on Southampton Island at the north end of Hudson Bay. He earned his degree in 1932 and remained at Cornell for many years as curator of the Louis Agassiz Fuertes Memorial Collection of Birds. The book ends in 1935, with Doc Sutton happily writing about the ambience of his life in the university. (Sutton is now George Lynn Cross Research Professor Emeritus of Zoology and curator of birds for the Stovall Museum of Science and History at the University of Oklahoma.)

So in a way this is a success story. There isn't much brag in Sutton's makeup, yet it does seem that from the time he was quite young he was a self-starter. For example, when he decided at age sixteen to take his bird painting seriously, he wrote to Louis Agassiz Fuertes, then the country's premier bird painter, and asked for help. Fuertes invited him for a visit, and to pay his way Sutton took a job on a road gang. Characteristically, he was quickly made a crew chief. All his life others have been appointing or electing him the man in charge of one thing or another.

But the success story is not the reason for the book. Sutton wants to talk about people and places, birds and bird painting, and the setting of a course for a lifetime's work in ornithology.

Many of his childhood memories are about birds—the stuffed pintail duck he proudly hauled around in a little wagon, the dead birds he dissected, his early sketches in hymnal margins of the birds and bird fragments he saw on the ladies' hats in church, the pet Bantam rooster he dropped in water to see if it could swim, the climb up into a tower to watch barn owls, the browsing after birds in the family dictionary, the dead northern harrier he wrapped in a stocking cap and took to school so that he could stow it in his desk and surreptitiously stroke it once in a while.

The possession of birds was vital to him. The "Simon Pures" in the amateur birding fraternity are going to be offended by Sutton's innocent enthusiasm in this regard. He recalls a crucial boyhood incident: Two male western tanagers were battling in midair, they grappled and fell to the ground close to him, and he tossed his cap on them and picked them up, one in each hand. Now the question was, what should he do next?

> I let the tanagers go—but not without qualms of a sort I had never felt. I didn't know what the birds were, and this ignorance hurt. Their lustrous black, white, yellow, and scarlet plumage was the most gorgeous I had ever held in my hands. All that beauty, that exquisite beauty, I wanted to keep, to have for reference, to show people by way of making clear how wonderful birds could be. Here was an opportunity of a lifetime. But what was I to do with them? How could I preserve them? As they flew off, I felt that I had not quite played fair with an important part of myself.

Years later, on a collecting expedition in Labrador, he shot a purple

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sandpiper, a species he hadn't seen before.

As I flexed the stubby legs and stroked the soft, thick plumage, a real thrill went through me. In a very special sense of the word, that most exciting of shorebirds had become mine, really mine, at last.

That was not the thrill of a trophy hunter. Sutton suffered great remorse after he botched an attempt to kill a polar bear with a shotgun—something he had tried on an impulse, thinking to make his mark among the Eskimos he was with. He tells us he decided to relate the story here "in hopes that other young men, eager to prove their mettle or win renown, will not make the same sad mistake." So for Sutton that was an aberration. The thrill of the bird in the hand had to do with something else—the physical and mystical experience of knowing a bird, the possession of that by which one is himself possessed.

The thrill Sutton felt must be connected to his impulse to draw and paint birds. Perhaps depicting something is another way of possessing it. Unfortunately, Sutton doesn't say what he thinks about that. The only passage in which he touches on why anyone would want to depict a scene or a creature is brief and unsatisfactory. His conclusion is that all art flows from "the desire to tell, the need to be on record, the will to communicate," and that doesn't get at the choice of subjects or the choice of medium.

*Bird Student* is occasionally irritating because of such incompleteness. Sutton tends to skip from anecdote to anecdote to philosophy to narrative to anecdote without joining them where they need joining or developing them into meaty units. This works well for him when he is writing about something that has its own built-in coherence, such as a long expedition. He has a talent for the neat, quick description of an event. But when he is covering ground between expeditions and adventures, the book becomes choppy.

This stylistic weakness is aggravated by his evident use of his autobiography to acknowledge his debt to a number of friends by mentioning their names. They appear in their allotted paragraphs—perhaps alone, perhaps not; the reader learns little or nothing about them, and they are never heard from again. Sutton also critiques some of his artistic efforts, a baffling exercise for the reader who doesn't happen to have the particular works at hand. Sutton would have benefited—as Lord knows we all can—from some good editing. Furthermore, readers familiar with earlier Sutton books—and there have been a good many—will be distracted by the frequent juxtaposition of stories they already know and those that are unfamiliar.

But these cavils aside, the book has much to offer, especially to those who haven't read any Sutton yet. As he shows, professional fieldwork can involve enormous amounts of effort, risk, and expense. A museum mounts an expedition into some remote part of the world for the sake of filling a small but important gap in a collection or to gather specimens for a particular display. Often the weather is contrary, vital equipment breaks or is lost or the need for it has not been anticipated, the birds aren't where they were expected, and the expedition achieves only a small fraction of its nominal goals. Nevertheless, a good deal may be accomplished that wasn't part of the plan—birds found, data collected, and descriptions written up. Ingenuity and adaptability are essential parts of a good field ornithologist's makeup.

One also becomes used to working under primitive conditions. A board nailed to a tree root becomes a skinning table. So does the top of a wooden chest in a schooner's hold, where the naturalist runs the risk of losing a favorite scalpel in the ballast of stones. And in the field, an ornithologist of Sutton's stripe routinely takes chances with his life because so many birds nest in high places. Sutton was a good climber, but on one occasion early in his career a rock pulled loose and dropped him off a cliff; he was lucky to escape with a few broken bones.

There are some good tales here. And a picture of the man emerges—self-effacing, generous, at times plagued by spiritual questions, not altogether sure of himself, but *very* determined and always caught and held by birds. Ornithology and bird painting for Doc Sutton seem to have been from the start not just a life's work but as central to his being as breathing.

*Michael Harwood, who has written several books on birds, is coauthor with his wife, Mary Durant, of* On the Road with John James Audubon *(Dodd, Mead and Co.).*

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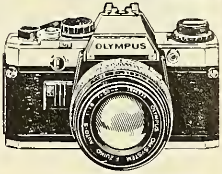

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# Telescope in Space

*An orbiting observatory is the newest apparatus at the service of astrophysicists*

**by Stephen P. Maran**

Astronomers scanning the sky from comfortable swivel chairs far removed from their customary telescopes are making revolutionary studies of stars and gas in our own and other galaxies. This seeming impossibility is made feasible by means of a telescope aboard an observatory spacecraft hovering over the Atlantic Ocean about 22,000 miles above the surface of the earth. This eighteen-inch telescope is equipped with two spectographs—instruments for photographing a spectrum—hooked up to computer display screens at two viewing centers, one in Greenbelt, Maryland, and the other outside Madrid, Spain. The spacecraft is operated by ground controllers in Greenbelt.

The NASA satellite carrying the telescope is called the IUE, for International Ultraviolet Explorer. It is in synchronous orbit, which means that it remains over the same region of the globe at all times, making an orbit once every twenty-four hours and thus keeping up as the earth below turns once on its axis.

The IUE has great operational flexibility. Ground controllers do not depend on occasional passes over far-flung tracking stations to get data from the IUE or to send it new commands. Instead, since it hovers nearly in place, the satellite is always in contact with the Greenbelt facility. When an observing astronomer requests that IUE point at a particular place in the sky, he or she waits until it does so and then sees the view through the satellite telescope on a computer console and a large, wall-mounted display screen. The star of interest can be readily identified and new commands to adjust the pointing of the telescope can be quickly sent if necessary.

The telescope beams the star's image into the entrance hole of a spectrograph. There, the light is spread out into a spectrum and focused onto an electronic image tube, which senses the dim ultraviolet light on its front end and produces an accurate duplicate image in glowing blue at its back. A television camera in the satellite scans the blue picture, makes a time exposure, and then produces an electronic signal that is telemetered to earth, run through computers, displayed on the screens, and recorded for posterity on magnetic tape. There is more to the process than that, but this should provide the general idea.

IUE is an astronomy milestone because it allows us to observe the ultraviolet light of much fainter and more distant objects than was possible with earlier satellites. Because ultraviolet light is absorbed by the earth's atmosphere, it must be observed from space. Hot stars are bright in the ultraviolet, while cool stars generally are dim in that part of the spectrum; hence, IUE is ideal for locating and studying hot objects in the cosmos. In addition, the thin interstellar gas can be investigated through its telltale "signature," a pattern of dark lines in the ultraviolet spectra of hot stars located beyond the gas cloud that is under study. The lines are caused by the gas, the stars simply acting as background lamps for the astronomer's convenience.

The observer sees the spectrum displayed shortly after IUE finishes an exposure and while the telescope is still pointing where the picture was taken. Thus, there is time to decide whether the exposure was adequate or needs to be repeated, and to see whether there is anything unanticipated in the spectrum (as there often is) that warrants a change in the observing directions. In other words, working with IUE is like using an ordinary mountaintop telescope, but one that the astronomer cannot touch.

This flexibility is in marked contrast to the limitations of earlier astronomy satellites. Failure to make the right estimates of exposure times or to choose the right wavelengths for observation in the rigidly preplanned observing schedules sometimes resulted in measurements that were not as useful as they might have been.

The "International" in IUE acknowledges that the satellite is a three-way undertaking by NASA, the European Space Agency, and the Science Research Council of the United Kingdom. Albert Boggess, a pioneer space astronomer at the Goddard Space Flight Center in Greenbelt, Maryland, is in overall charge of the satellite. For two eight-hour shifts a day, the observatory is used by American astronomers, who work in a basement room at the Goddard Center. During the other eight hours, the Europeans have their turn at a corresponding fa-

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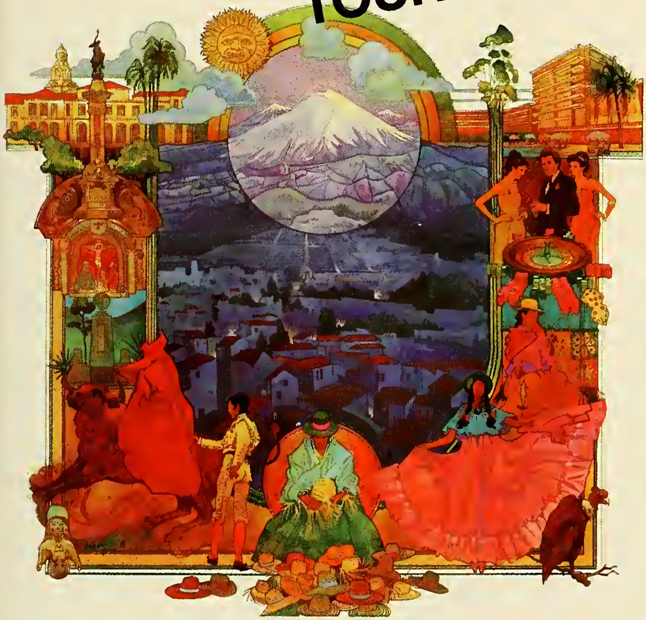

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cility near Madrid. The setup at Goddard is much like that at a conventional observatory, with star catalogs, sky atlases, and even a microwave oven to warm up midnight snacks.

IUE's ability to discriminate hot objects from cool ones has led to several important findings. One of the latest is the discovery that two well-known cepheid variable stars actually are binary systems. A cepheid is a yellow giant star that pulsates, making its brightness increase and decrease in cyclic fashion. Cepheids are very bright stars and have been intensively studied.

Usually you can tell if a star is a binary by looking for moving lines in its spectrum that shift back and forth gradually as the members of the binary system go around their orbits. The shifting is due to the Doppler effect. If one of the two stars of a binary is much brighter than the other, you find only one set of lines in the spectrum, since the light of the fainter star is lost in the glare of the brighter one. Nevertheless, you can still tell you are dealing with a binary star because the single set of lines does shift back and forth.

In a cepheid's spectrum, only one set of lines is found. These lines also shift back and forth, but that is because the star is pulsating and the Doppler effect makes them shift as the star's surface pulses in and out. That effect masks any possible shifts due to orbital motion. However, astronomers from the Naval Research Laboratory in Washington, D.C., found a way to identify binary systems among cepheid variable stars. In two of the half dozen cepheids that they studied with the IUE, they found excess ultraviolet light beyond that expected from a yellow star. Further, the ultraviolet spectra had the wrong "slopes," meaning that the way in which the ultraviolet brightness changed with wavelength did not correspond to the expected circumstance for a yellow star.

In the case of the cepheid Eta Aquilae, for example, the amount and slope of the excess ultraviolet light correspond to what we would receive from an ordinary white star, such as Sirius or Vega, if it were placed at the distance of the cepheid. One might argue that excess ultraviolet radiation could be produced by some unusual means in a complex, pulsating star, so that it is unnecessary to postulate the existence of a companion star. But there is a fatal objection to this argument: Eta Aquilae gets noticeably brighter and fainter as it pulsates rhythmically once a week. No such changes were found in the ultraviolet light; hence a companion, nonvariable white star must be present. Much smaller than the cepheid, the white star is lost in the visible spectrum where the cepheid shines so brightly, but since the white star is much hotter, it dominates the ultraviolet radiation from the system.

One of the most interesting discoveries made since IUE was launched in January 1978 was the observation of intense blue cores in globular clusters. The latter are spherical aggregations of hundreds of thousands to millions of closely packed stars (see "Stars by the Cluster," *Natural History*, October 1976). As observed with ground-based telescopes, the star images seem to blend together at the center of a globular cluster, so that individual stars cannot be discerned. Further, the cluster light is dominated by the glow of numerous red giants.

Six globular clusters were examined with IUE by a team of scientists led by Andrea Dupree, a noted astronomer at the Center for Astrophysics in Cambridge, Massachusetts. To appreciate what the team found, you need to know what a spectrum looks like. As shown on an IUE display screen, a spectrum consists of one or more long, straight, diagonal bands. Positions along the length of a band correspond to the wavelengths of ultraviolet light. The width of the band at any point corresponds to the size of the image of the target, measured along a certain axis.

If the target is a single star with a pointlike image, the spectral band will be narrow and of uniform width, but if the target is spatially extended, the width will be greater. If a star cluster were composed of identical stars, its spectrum would be of uniform width, since stars at every place along the image axis would produce light over the same range of the spectrum.

Dupree found, however, that the ultraviolet spectrum of a typical globular cluster, such as M15 in Pegasus, is a tapered band, narrower at the shorter-wavelength end than at the longer-wavelength end. This implies that the shorter ultraviolet wavelength radiation is produced by a group of hot stars that must be concentrated in a small region. In the case of M15, the cluster as a whole is roughly ninety light-years in diameter, but the hot stars are located within a central zone of only one light-year.

The observed short-wavelength radiation can be most readily explained as the product of about twenty luminous blue stars. These are not young blue giant stars of the type found in Orion, for globular clusters are too old to contain such objects. Rather, they must be of a less familiar type, called horizontal branch stars after their position in a technical diagram used for classifying stars.

The difficulty with this explanation is that the theory of globular clusters tells us that a given type of star should not be concentrated more strongly at the center of a cluster than other member stars unless it is a very massive type, and horizontal branch stars are not exceptionally heavy. Dupree's way out of this dilemma was to suggest that the concentrated horizontal branch stars are binary systems. Two stars are heavier than one (with some exceptions, of course), so the binaries would be more strongly concentrated at the cluster center than individual horizontal branch stars.

One of the best examples of the use of IUE to study the interstellar gas is an investigation by two astronomers from the University of Wisconsin in Madison. They adopted bright blue giant stars in the Large and Small Magellanic Clouds, two neighbor galaxies of our own Milky Way, as background lamps to study the gas of the Milky Way at high altitudes above the galactic disk. The IUE spectra revealed that there is indeed a thin gas up there, where there are few if any stars, and that the gas is very hot, perhaps 100,000°C. The gas, called the galactic corona by the Wisconsin astronomers, is not primordial, for it contains atoms of carbon, oxygen, silicon, and other elements that must have been made by nuclear reactions within stars. How did this gas get up there? The best guess is that it comes from the disk of the Milky Way, where it was heated by supernovae explosions and then rose upward like steam. This theory remains to be proved, but the observations are valid. Here again, IUE struck pay dirt, or perhaps I should say "hot stuff."

*Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.*

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# A Mummy's Travels

Working in the American Museum of Natural History presents occasional problems. One morning last month, for example, the staff of *Natural History* was greeted by the suffocating odor of mothballs. The cause was soon revealed: the mummies in the mummy storage area, which is adjacent to the offices of *Natural History*, had just received a mothball change. And since only a plasterboard wall that reaches halfway to the ceiling separates the quick and the dead, the fumes easily found their way over the top and down again.

The mummy storage area houses most of the human remains (aside from bones) that have, through the years, become part of the Museum's collection. Stored in black tin boxes are burials and mummy bundles from the Americas, trophy heads wrapped in exquisitely woven textiles, and thirty-odd Egyptian mummy heads loaned by the Metropolitan Museum of Art some fifty years ago. Not everything is hidden away, however. In the center of the storage area rest several exhibit cases from the dismantled South American Hall.

By far the most striking sight in these cases is Copper Man, a South American copper miner killed about A.D. 800 when the tunnel in which he was working collapsed. It is not hard to imagine how he got his name: his skin is stained with dull green copper oxides, except where oozing resins have created the illusion of a shiny, metallic surface. His body is remarkably well preserved, and unlike other naturally mummified bodies, only minimal shrinkage of skin occurred. One can trace the details of his musculature and facial features. His hair is neatly braided, and he wears two strips of coarse cloth as a loin covering.

The complete history of Copper Man has recently been pieced together by Junius B. Bird, curator emeritus in the Department of Anthropology. His research, published by Dumbarton Oaks in a volume on pre-Columbian metallurgy, covers not only the anthropological significance of the mummy but also its discovery and subsequent transit through the fairs, marketplaces, and warehouses of Chile and the United States.

Copper Man was unearthed in 1899 in an ancient, collapsed mine shaft at a small mineral claim in the Atacama Desert of northern Chile. Found with him were four coiled baskets, a rawhide bag, a stone hammer, and a spadelike stone implement. He had probably been removing copper ore in a crawl space, hammering and prying out loose rock from cracks and fissures, when the ceiling shifted, pinning him. His arms are still extended in a working position.

According to a letter found by Bird, the discovery of the mummy precipitated an argument between the American owner of the mine, William Matthews, and the Frenchman who was renting it, a M. Pidot. Pidot argued that because the body assayed at slightly under one percent copper, it was ore, and therefore belonged to him. Matthews replied that Pidot had only rented the mine, not the miners.

After a year of negotiation, they finally arrived at a satisfactory financial arrangement and sold the mummy for $1,000 to Edward Jackson, an American entrepreneur living in Antofagasta, Chile. With characteristic Yankee enterprise, Jackson set it up in his house and charged a fee for viewing it. Presumably business was slow, because he soon entered into a partnership with a fellow Antofagastan, Perez de Arce, who was to take Copper Man on tour to Valparaiso and Santiago.

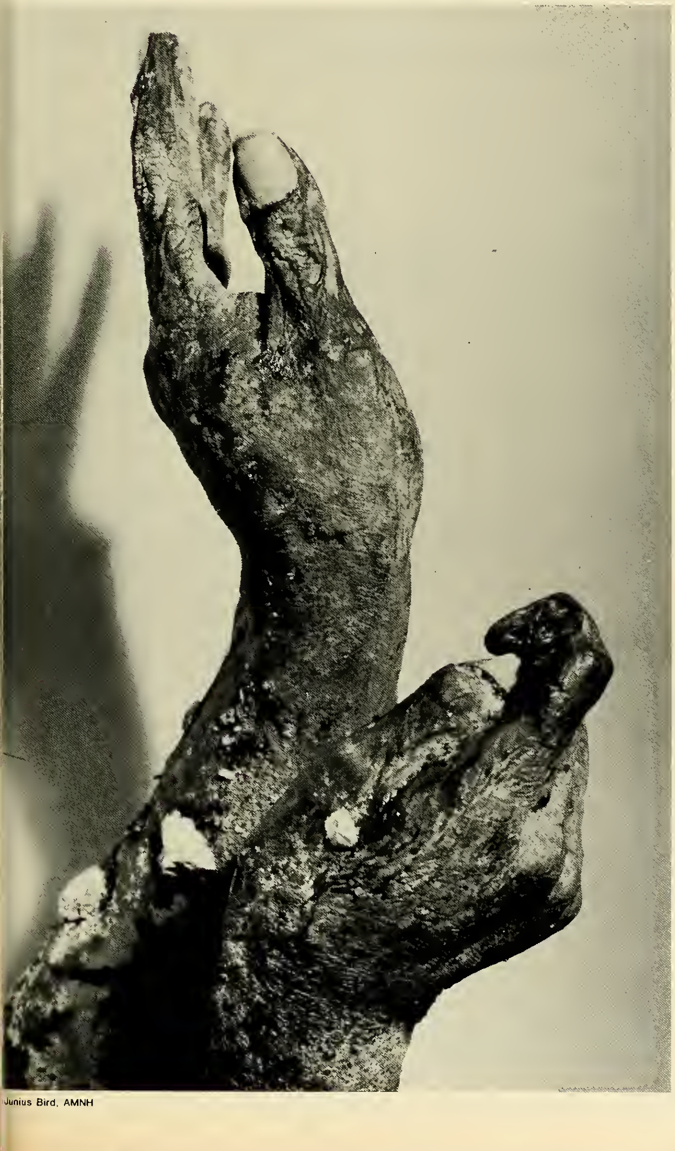
When a few months had passed and no profits were forthcoming from de Arce, Jackson decided the mummy was more trouble than profit and made arrangements to sell it. He soon found out that, unfortunately, getting rid of a mummy was not that easy.

Through the efforts of his brother, Jackson sold the mummy to two businessmen, Srs. Torres and Tornero, for $15,000—$5,000 cash and $10,000 to be paid in three months. Torres and Tornero brought Copper Man to the United States, and after some trouble with the Customs Service displayed it at the Pan-American Exhibition in Buffalo, New York, from May 1 to November 2, 1901. To stir up interest, they printed a pamphlet entitled: *Human Petrification: The Only Specimen in Existence of a Perfectly Preserved Body From a Race Which Is Now Entirely Extinct.*

During the exhibition, excited spectators swarmed into the Chilean building, sometimes climbing over the railings and standing on the furniture to look at the remarkable mummy. At one point, the police temporarily roped off the area after frantic crowds smashed the mummy's glass case.

When the exhibition closed, Torres and Tornero put Copper Man up for sale at an enormous price—fully expecting to become rich men—but there were no takers. They optimistically prolonged their stay in the United States, where they sank deeper and deeper into debt. After a creditor seized the mummy as security, Torres and Tornero returned to Chile thanks to the largess of the Chilean consul.

Because Jackson had never been paid the $10,000 still owed him, the mummy was legally his, but his efforts to regain it were brushed aside by the creditor. In desperation he gave $500 in gold coin and power of attorney to an acquaintance, Raimundo Docekal, who was going to the States



Junius Bird, AMNH

and promised to get the mummy back. After surviving a shipwreck in the Strait of Magellan, Docekal arrived in New York, made a deal with the creditor, canceled the $10,000 debt, sold the mummy, and disappeared.

In a letter to F.D. Aller, Esq., Jackson later wrote: "I looked for him [Docekal] when I was in New York but found it rather too big a place to find him."

After discussing in detail his income and expenses regarding Copper Man, he continued: "I made only $200 on it, and I came to the conclusion that it is a sin to deal in dead men's bodies, and shall not do so again.

"Mummies went up terribly in the market after our find."

The mummy apparently bounced around New York and was finally acquired by the American Museum of Natural History in 1905 through the generosity of J. Pierpont Morgan.

How much Morgan and the Museum paid for the mummy is a mystery. The owner had initially asked for $100,000 but probably got only a fraction of that amount. The proud director of the Museum, Prof. Hermon C. Bumpus, put Copper Man on display almost immediately.

In 1953, two scientists drilled out cores from the body for study, and discovered that the copper oxides had only permeated the skin and were not

*The hands of Copper Man, still extended in a working position, show the remarkable preservation of the 1,200-year-old mummy. The prehistoric South American copper miner lost his little finger (and little toe) to souvenir hunters at the time of his discovery in 1899.*

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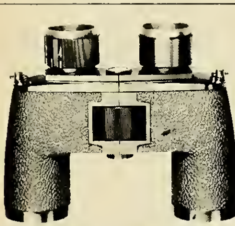

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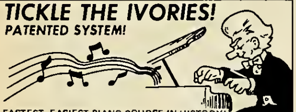

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present in the inner tissues. They also confirmed that the mineral compounds in the surrounding earth had created a sterile environment for the body, preventing bacterial decay.

Junius Bird theorizes that the blood forced into the extremities of the miner's body when he was pinned by the rock probably resulted in the mummy's lifelike preservation. If the skin dried and hardened while distended, the normal shrinkage that takes place during mummification would not have occurred. Bird notes that the Atacama Desert is one of the world's driest regions, an environment where a body could have desiccated this rapidly.

Copper Man remained on display until 1967, when his case was moved into the mummy storage area.

There is some debate in the Anthropology Department over whether the Museum should exhibit Copper Man again. Some curators feel it is improper to display human remains for popular viewing. Bird, however, disagrees. He feels that, as the Americas' only prehistoric miner found with his tools, the mummy would be an important part of the planned hall of South American peoples. "Mining," he says,

> has always been a hazardous occupation. This poor fellow was killed while working with the most primitive of tools under extremely difficult conditions. I feel that if he had anything to say about it he would prefer that people see him as he is so they may better understand what was involved in the making of tools, weapons, ornaments, and other metal products before Europeans came to the Americas.

But at least until the South American hall is built, Copper Man will remain in the gloom of the storage room, being disturbed only when it is time for a change of mothballs.

*Douglas J. Preston*

### Discovery Tours

The Museum is offering members and friends a chance to discover the wildlife of East Africa on safari with Richard G. Van Gelder, curator of mammals. Participants will explore the major game reserves of Kenya and Tanzania, including Nairobi National Game Park, Mount Kenya, Ngorongoro Crater, Serengeti National Park, and Lake Manyara National Park. There will be a brief mid-safari rest in the Seychelles. The first East African safari, scheduled for February of 1981, is booked; however, a second safari in late February still has space available. For more information, write to Discovery Tours at the Museum.

### Tibetan Music

The Society of Myth and Tradition, publishers of *Parabola* magazine, and the Museum's Department of Education are presenting an evening of Tibetan music in the Auditorium on Wednesday, July 2, at 7:00 P.M. Three musicians will sing, chant, and play Tibetan music on drums and trumpets, and Ernest McClain, professor of music at Brooklyn College; Huston Smith, professor of religion and philosophy at Syracuse; and Lobsang Lhalungpa, translator of Tibetan texts, will discuss the music and its relation to Tibetan Buddhism. The program is free to all Museum visitors.

### African-American Summer Festival

On Friday, July 18, and Saturday, July 19, the Museum is planning a series of events focusing on the culture, and traditions of African-Americans, including live music and dance performances.

*Films for Kids.* Friday from 11:00 A.M. to 3:00 P.M., and Saturday from noon noon until 4:00 P.M., a series of short films for children will be shown in the Auditorium. Highlights include *The Lion Game,* Bushman children playing; *A Story, A Story,* an animated African tale about a spider; and *Desert Caravan,* the life of a nomad boy of the Sahara.

*Films for Adults.* Running concurrently with *Films for Kids* will be a series of films in the People Center. Among them are *I Shall Moulder Before I Shall Be Taken,* about the Djukas of Surinam, South America, who escaped from slavery; *Bitter Melons,* in which an old blind Bushman celebrates his hunting-gathering life in song; and *Men of Bronze,* about the first black regiment of World War One.

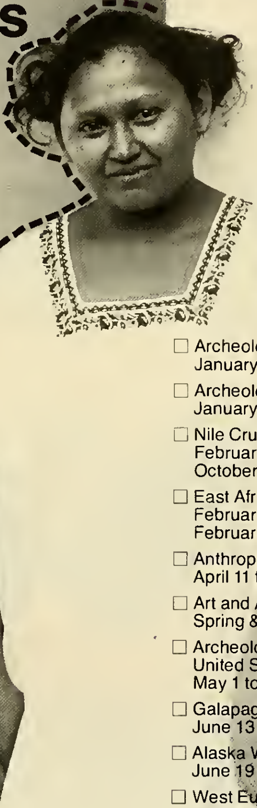
*Bamiki Dance Group.* On Friday at 1:00 P.M. at the 77th Street entrance, young performers from Lincoln Square Neighborhood Center's Bamiki dance group will present *The Bird with the Most Beautiful Song,* a program of African mime and dance.

*Ladji Camara African Dance and Music Ensemble.* On Saturday at 1:00 P.M. at the 77th Street entrance, this acclaimed ensemble will perform traditional African dances and songs.

*No Maps on My Taps.* On Saturday at 2:00 P.M. in the Education Hall, this 1979 film about three old-time Harlem tap dancers will be shown.

*Tap Dance Demonstration.* Eleanor Harris, noted choreographer and dance teacher, will demonstrate tap dancing and invite audience participation on Saturday at 3:00 P.M. in the Education Hall.

For more information, write to the Museum's Department of Education.



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**Trilobites** (p. 46)

Details of the distribution of calmoniids, including the influence of plate tectonics, can be found in the scientific report "Biogeography of Silurian and Devonian Trilobites of the Malvinokaffric Realm," by N. Eldredge and A.R. Ormiston, in *Historical Biogeography, Plate Tectonics, and the Changing Environment*, edited by J. Gray and A. Boucot (Corvallis: Oregon State University Press, 1979). A well-illustrated introductory text on historical geology, *Evolution of the Earth*, third edition, by R. H. Dott, Jr., and R. L. Batten (New York: McGraw-Hill Book Co., 1980), discusses continental drift and the basic features of evolutionary theories. A multiauthored symposium, *Vicariance Biogeography: Congruence of Earth History with Plant and Animal Distributions*, edited by G. J. Nelson and D. E. Rosen (New York: Columbia University Press, forthcoming), offers a balanced view of contemporary method and theory in biogeography. "A Trilobite Odyssey," an earlier article by N. Eldredge and M.J. Eldredge, can be found in the December 1972 *Natural History*.

**Salmon** (p. 52)

A. Netboy's latest book, *Salmon: The World's Most Harassed Fish* (London: André Deutsch, 1980), discusses the most recent information on the life histories and survival problems of Atlantic and Pacific salmon. An earlier book by Netboy, *The Salmon: Their Fight for Survival* (Boston: Houghton Mifflin, 1974), also provides background to "Those Salmon Keep Butting Those Dams" and should be available in most libraries. *Salmon Fishers of the Columbia*, by C. L. Smith (Corvallis: Oregon State University Press, 1979), is an illustrated popular history of the salmon-canning industry. In *Pacific Troller: Life on the Northwest Fishing Grounds* (Anchorage: Alaska Northwest Publishing Co., 1978), F. E. Caldwell gives a firsthand description of life on a troller.

**Afghanistan** (p. 64)

V. Gregorian's *The Emergence of Modern Afghanistan: Politics of Reform and Modernization 1880–1946* (Stanford: Stanford University Press, 1969) is a modern history with special emphasis on socioeconomic development and the policies that determine it. *Afghanistan*, by L. Dupree (Princeton: Princeton University Press, 1973), takes a more anthropological approach and discusses the processes involved in changing from a tribal society to a nation-state. The social, cultural, economic, and political trends in contemporary Afghan society are the subjects of *Afghanistan in the 1970s*, edited by L. Dupree and L. Albert (New York: Praeger Publishers, 1974), a collection of essays by Afghans and Americans. Of particular interest are Baqui Yousefzai's "Kabul University Students: A Potential Political Force?" and William Sayres's "Old Trails and New Paths in Education." R. Akhramovich, a leading Soviet expert on Afghanistan, gives the Soviet point of view in *Concerning the Recent Stages in Afghanistan's Social History*, published in Moscow in 1967. An anthropological analysis of two ethnic groups in northern Afghanistan along the Soviet border is presented by M. N. Shabrani, a native of the area, in *The Kirghiz and Wakhi of Afghanistan* (Seattle: University of Washington Press, 1979). M. Slobin writes of his two-year study of the relationship of music and ethnic identity in his *Music in the Culture of Northern Afghanistan* (Tucson: University of Arizona Press, 1976). The ethnographic and trading situation in central Afghanistan is discussed in "Nomad Expansion and Commerce in Central Afghanistan," by K. Ferdinand (*Folk*, vol. 4, 1962, pp. 123–59).

*Katharine D'Agosta*

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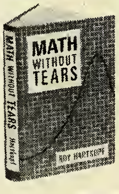

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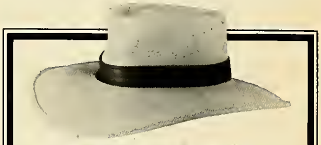

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# Stalking the Cultivated Gooseberry

*It takes work to find a gooseberry*
*or even a gooseberry fancier*

**by Raymond Sokolov**

> I am going to turn over a new life and I am going to be a very good girl and be obedient to Isa Keith, here there is plenty of gooseberries which makes my teeth watter.
>
> Marjorie Fleming (1803–1811)

Before her untimely death at the age of eight, the precocious British diarist Marjorie Fleming had already acquired her nation's taste for the tart and hairy fruit of *Ribes grossularia.* For my own part, as a more or less typical American, I did not even try a gooseberry until, as a nominally mature 22-year-old Fulbright student, I sat down to dinner at Wadham College, Oxford, and having picked desultorily at the main course, braised ox heart, fell upon the dessert—gooseberry compote—with a gusto that diminished after the first bite.

The once-green and translucent berries had lost their shimmer in the canning process, but I could still make out the delicate, longitudinal striping on their skins. The actual flavor did not then mightily attract me. Over the years, however, I have put away this childish phobia and ceased to be a gooseberry fool. Now, back in the United States, I have a new problem. Fresh gooseberries are almost as rare as the great auk.

Prepared gooseberry products are easy enough to find in this country. On a recent visit to a specialty store, I turned up two kinds of gooseberry preserves (one English, one from Oregon) and a jar of canned whole gooseberries from Germany. But fresh gooseberries seemed to be only a midsummer's dream until a hot tip from a horticulturally alert friend sent me out to the eastern tip of Long Island and beyond, by ferry over Gardiner's Bay, to Shelter Island.

Stalking the cultivated gooseberry on that seagirt and historic summer mecca was soft work, but I got there just in time. Kathleen Brown, who had been tending her opulent garden on the island for seventeen years, was just packing the last of her belongings and preparing to move to a planned retirement community in southern California.

The berry patch was still in place, however, on a small plot behind a cheerful yellow ex-privy in the middle of a sunlit lawn bordered by a mob of lilies. Tangled branches with long thorns and curly green leaves were tied off in sections to make it easier to pick fruit during the short season that runs, on Shelter Island, from the end of June until late July.

The stand of shrubbery wasn't particularly imposing but for years it provided Mrs. Brown with enough berries for a cash crop. In 1977, her best year, she picked twenty-seven quarts and sold most of them at a local farm stand. You couldn't call it a phenomenal output, but the outsider, knowing how unlikely it is to find such a thing at all, wondered why Mrs. Brown had turned her green thumb in this unusual direction. Was it a case of anglophilia or a yearning for the exotic?

"I didn't know there was such a thing as a gooseberry," she said. "A friend gave me a bush. She had a lot. I layered more every year. Gooseberries are no trouble at all."

In the mild climate of her garden, under her watchful eye, this may be so, but the fact is that the gooseberry has had a hard time of it in this country, even though, in the beginning of British colonization, there was every cultural reason for it to have prospered on American soil.

Apparently, early settlers did try to transplant European gooseberries, but they failed. *Ribes grossularia,* which had been cultivated in northern Europe since as early as the sixteenth century, did not adapt to our climate. Imported shrubs succumbed to a fungus known as gooseberry mildew, which attacked the leaves, twigs, and fruit of the plant, covering it with its weblike mycelium in the spring.

All was not lost, however. In the nineteenth century, a native wild gooseberry turned up in New Hampshire and Vermont. By 1846, Abel Houghton, Jr., of Lynn, Massachusetts, had cultivated it, probably from seed of the plant now called *Ribes hirtellum.* Subsequent hybridization with European strains led to viable cultivars with commercially exploitable fruit, inferior in flavor to the European gooseberries, which can be eaten out of hand, but still a delectable berry for jams and cooked desserts (see recipes).

High hopes for the American gooseberry soured when it transpired that it, like its *Ribes* cousin, the black currant, played host to a virulent fungus, *Cronartium ribicola,* which attacks five-needle pines. In fact, the so-called white-pine blister rust is such a threat to the timber industry that federal and state laws regulate shipment and cultivation of gooseberries and black currants.

Clearly, the white pine has a far more important role in American life than the gooseberry. And in the conflict between the two plants, the gooseberry has lost out. Production figures

W H. Hodge, Peter Arnold

for American gooseberries are hard to come by, but the annual crop is not large. In its statistical tables the U.S. Department of Agriculture lumps gooseberries together with "miscellaneous fruits and berries." The department did publish numbers for frozen gooseberries until 1970, when 540,000 pounds of the fruit were processed, as compared with some 29 million pounds of blackberries and 202 million pounds of strawberries.

It would be unfair to lay the blame for the meager gooseberry harvest entirely at the door of the timber lobby. Fruit growers would, I am sure, have found a way to grow gooseberries safely and in quantity if there had been a strong public demand for them. But the high acidity of domestic gooseberries has undoubtedly played a real part in making them unpopular. A sweet-toothed populace eager for convenience foods will opt for sweeter fruits that can simply be popped into the mouth.

And then there is the matter of the name "gooseberry" itself. It makes the fruit sound funny, especially the way we Americans pronounce the word. In England, they disguise the poultry aspect of their gooseberries with a pronunciation that sounds like "guzbry." When you hear it you don't think of a goose. This is etymologically reasonable, since the term may very well have nothing to do with geese at all. No one knows for sure, but it is not hard to see how "gooseberry" may have evolved from the Dutch *kruisbezie*, the German *Krausbeere*, or the French *groseille*.

Even if gooseberry does have some fanciful connection with geese, the domestic species and hybrids still offer an alternative to more familiar berries for anyone who wants to try a complex and distinguished summer fruit. Some farm stands and fancy fruiterers carry them. And the home gardener can find shrubs for sale at nurseries. I recently saw a small plant for sale in Manhattan at $5.99.

The standard method of propagation is mound layering. After severe pruning, so that the plant has been cut back almost to the ground, heap soil around the bases of the stems, which will send out roots. Then set out the rooted stems and let them develop into new plants.

Mrs. Brown layered her gooseberry patch by cutting into long stems on the bias, painting the cut with a commercial rooting chemical and burying the cut area underground. A brick was placed over each buried piece to hold it in place. She did this at the end of the season and never cut her plants back, thereby probably reducing her overall crop since the heaviest output normally occurs on wood under three years old.

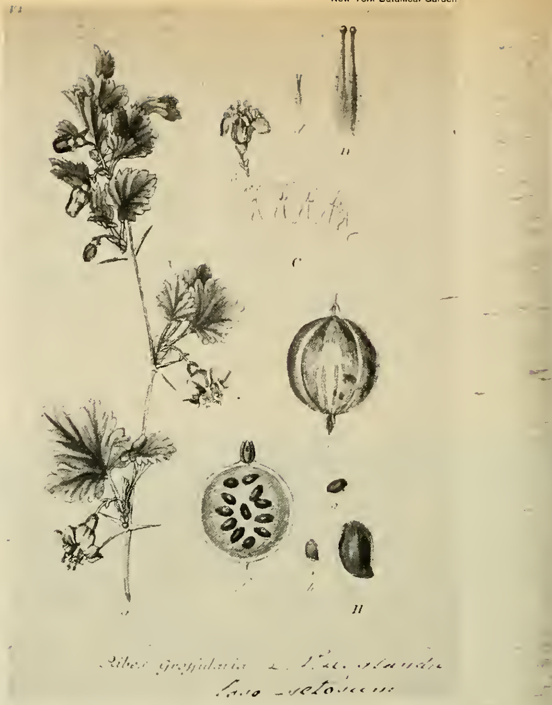
But Mrs. Brown has a green thumb. She knew how to keep gooseberry maintenance to a minimum. In early May, she fed her patch with 5-10-5 fertilizer. She sprayed the bushes with Sevin, one tablespoon per gallon of water, to hold down insect infestation. Then, all she had to do was wait and pick the berries before the birds got to them.

> You pick them when they're half green, with a red blush. When they've turned solid red and started to fall on the ground, it's too late. In the beginning, I waited until they were all red and picked them very carefully. Then I learned that earlier was better. I was so amazed that you could take these green gooseberries and cook them and then see them turn red.

Color will vary among varieties, but the result is the same, plenty of fruit for ten to twenty years, after two or three years of waiting for the patch to take hold. Gooseberries will not do well in hot, dry climates. But these are hardy plants, whose range extends nearly to the Arctic Circle. Many people leave them alone altogether. With any luck, Mrs. Brown's patch will survive and continue to bear fruit, even after she leaves for Chula Vista and abandons her beloved gooseberries to a new, possibly uninterested owner.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

New York Botanical Garden



### Gooseberry Fool

(Traditional English recipe adapted
from Elizabeth David's *Summer Cooking*)

1 pound hard green gooseberries
10 tablespoons sugar, approximately
½ cup heavy cream, whipped

1. Cook the gooseberries and sugar in a double boiler until the berries are quite soft. There is no need to top and tail the gooseberries.
2. Push the gooseberry mixture through a strainer or run through a food mill. Chill.
3. Stir in the whipped cream. Add more sugar if the fool is too acid. Serve very cold.

Yield: 3–4 servings

### Mary Peacock and Amanda Stinchecum's Illinois Gooseberry Fool

1 quart gooseberries
1¼ cups sugar
5 egg yolks
1 pinch salt
1½ cups scalded milk
1 teaspoon vanilla
1 cup heavy cream, whipped

1. Cook the gooseberries until soft with ¾ cup sugar and ¼ cup water. Mash a bit.
2. Beat the egg yolks lightly together. Then gradually beat in the remaining ½ cup sugar and continue beating until the the mixture lightens in color and forms a ribbon.
3. Beat in the salt, then the scalded milk in a slow stream.
4. Heat the egg mixture over boiling water or over low to moderate heat until it thickens. If some scrambling of the yolks occurs, pour the mixture through a fine strainer.
5. Stir the vanilla into the egg mixture. Cool. You will get a light, pourable custard sauce.
6. Pour the custard sauce (crème anglaise) over the fruit mixture.
7. Top with whipped cream just before serving.

Yield: 4–6 servings

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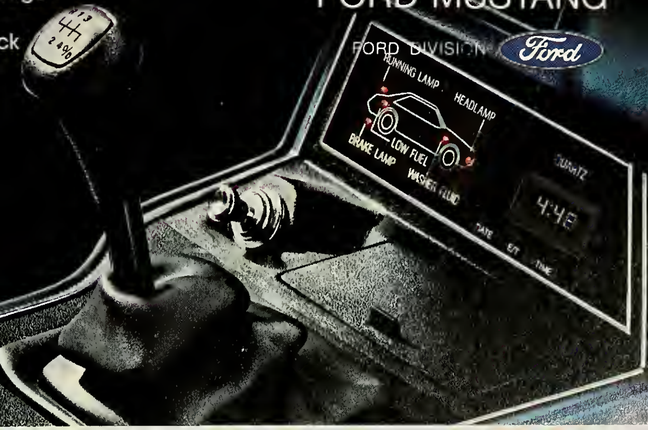

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# NATURAL HISTORY

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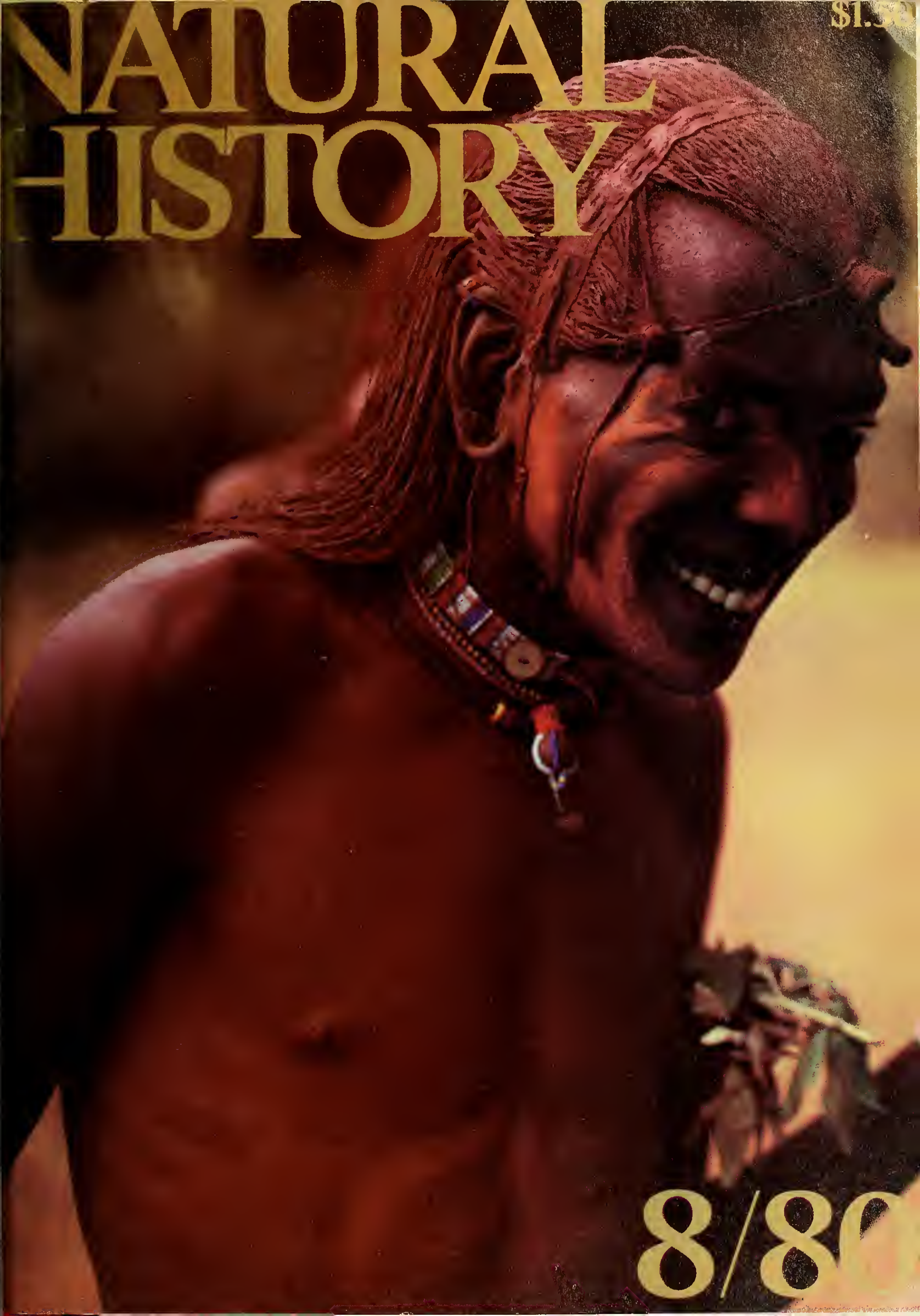

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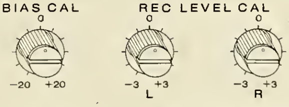
Of course, fitting three heads into the tiny cassette shell openings, accurately, for years on end, is no small feat. Especially since the slightest alignment error can cause significant high-frequency loss. So to make sure you hear all the sound you're supposed to, Sony has created a major breakthrough in head design with a unique independent suspension system.



This remarkable system allows incredible precision and consistency in head alignment. And just as important, there's no longer the need for you to realign the heads from one tape to the next as in other cassette decks. Equally innovative is that only Sony uses heads that are a combination of Sendust and Ferrite. So you get the advantages of both, without the disadvantages of either.

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Obviously we could fill pages on the technological advancements in the K81. Like the two 16-segment, LED Peak Program Meters. Or the special "Auto-Space Record Mute" which allows you to blank out commercials and other interruptions.

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FEATURES AND SPECIFICATIONS: Independent-suspension three-head design with switchable tape-source monitoring/Metal tape recording and playback/Sendust and Ferrite record and play heads/Two-motor closed-loop dual-capstan tape drive/Microprocessor solenoid-logic transport with feather-touch controls/Bias and record level calibration with built-in test tones/16-segment LED Peak Program Meters/Auto-space record muting/Auto-play repeat capability/Optional remote control/Wow and flutter (WRMS) 0.04%/Frequency response (metal) 30 Hz-18 kHz ± 3 dB/Signal-to-noise ratio (metal or FeCr, Dolby off) 60 dB.

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# NATURAL HISTORY

*Vol. 89, No. 8, August 1980*

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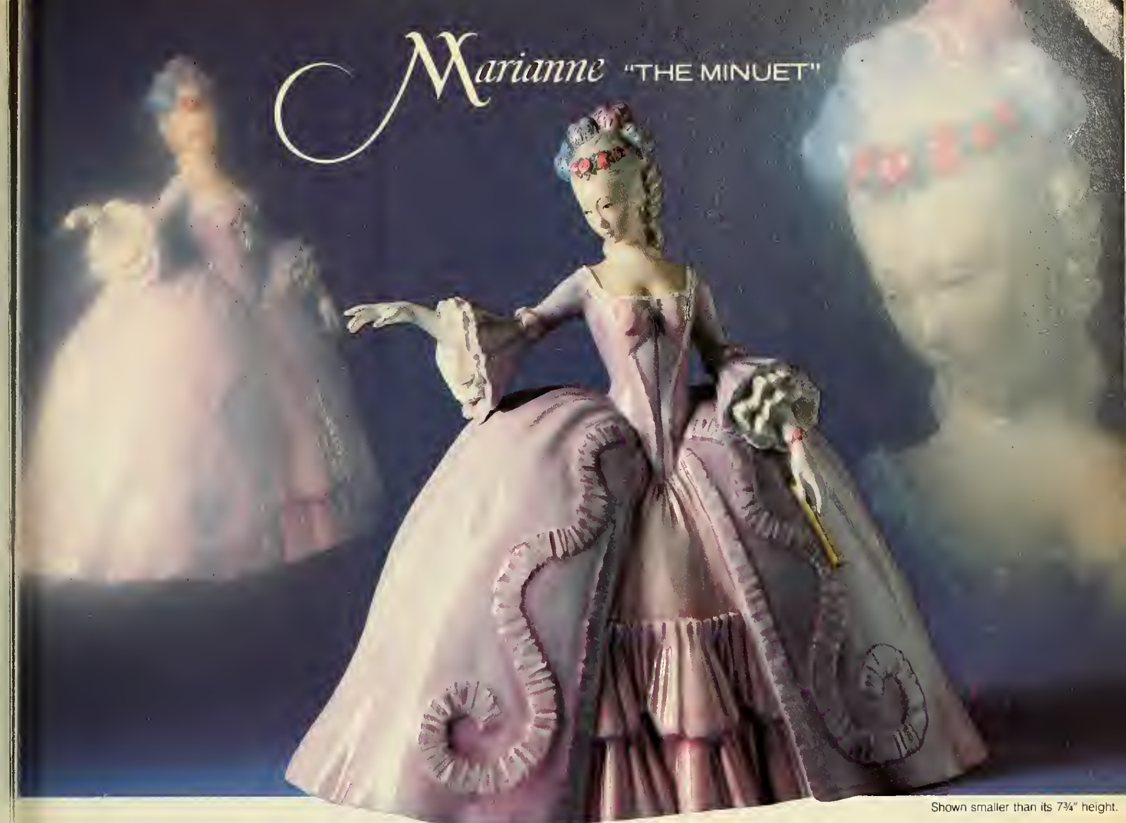
# *Marianne* "THE MINUET"



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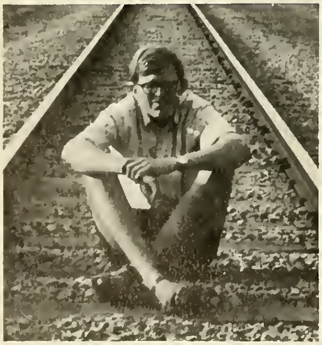
# Authors

"I am something of a compulsive writer, artist, and photographer," explains **Paul A. Johnsgard**, "lurching from one to another of these activities like a drunken barfly, and usually working on at least three books simultaneously." True to his word, Johnsgard, a professor of zoology at the University of Nebraska, reports that he is at work on a book on the shorebirds of the world, another on the grouse and ptarmigans of the world, and a third on the hummingbirds of North America. Fieldwork associated with the production of these ambitious tomes will cover a goodly chunk of time over the next several years. Somehow, he also finds the opportunity to contribute regularly to *Natural History*.

The Academy of Natural Sciences in Philadelphia, where **Daniel Otte** is an associate curator of entomology, has a huge collection of horned beetles. Otte writes, "It occurred to me that these animals have never been measured as horned mammals have, and that the existence of certain morphological patterns would contribute to the theory of horn evolution." When not measuring the length of beetle horns and pondering their evolution, he pursues research on the behavior, biogeography, and systematics of North American grasshoppers and Australian and Hawaiian crickets. A native of South Africa, Otte also serves as adjunct professor of biology at the University of Pennsylvania and is hard at work on a three-volume handbook on North American grasshoppers.



Cheryl Sonnichsen

Photographer **Carol Beckwith** first went to Kenya in 1974. She bought a 45-day ticket but stayed for eight months. "I was drawn to the Maasai visually and intrigued by their life style," she says. "Here were a people blending in with their environment, who rejected the modern world because they found their traditional ways superior to ours." Only much later did Beckwith recognize that the Maasai faced cultural extinction through the modernization of the Third World. Four years after her initial trip, Beckwith returned to Kenya to work on her book on traditional Maasai culture from which the article in this issue was adapted. A graduate of Goucher College in Maryland, Beckwith spent two summers at the Skowhegan School of Painting and Sculpture in Maine and did graduate work at the School of the Museum of Fine Arts in Boston. Her paintings and photographs have been exhibited in solo and group shows over the past decade.

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A Maasai from a family of many children, author **Tepilit Ole Saitoti** combines within his person both the traditional and modern worlds. He tended cattle, sheep, and goats until the age of eight, when his father sent him to a government school. After eight years of schooling, he became a traditional warrior and proved himself brave in that role by killing a lion that attacked his father's herd. In 1967, Saitoti joined the Tanzania National Park Service and soon became a ranger and guide. Four years later he was selected to star in *Man of the Serengeti*, a National Geographic Society film. After obtaining a language certificate at the Goethe Institute in Munich, Saitoti flew to Los Angeles to narrate the film. He then toured the American university circuit showing the film. In 1976, he received an honors B.F.A. degree in creative writing from Emerson College in Boston, after which he continued his Western education at the University of Michigan, where he earned a master's degree in environmental studies. Saitoti and Beckwith met initially in Boston at an exhibition of her African paintings.

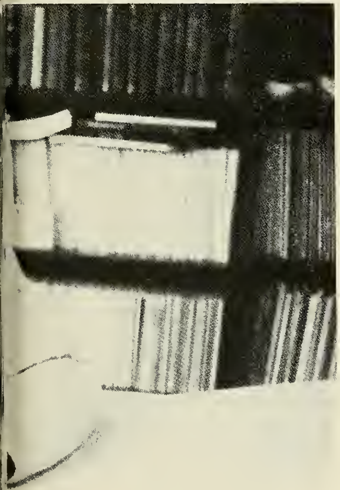
In 1969, **William H. Whyte** helpe draft the "Plan for New York City" a design drawn up for the city's Pla ning Commission. He thought then directly observing "just how the cent city functioned or nonfunctioned The next year, at Hunter College, h conducted a course called "Expe ence of the City." This led to t founding of the Street Life Project an attempt to observe the city sy

As U.S. chairman of the Area on Prevention of Water Pollution of the U.S.-U.S.S.R. Joint Agreement on Environmental Protection, biologist **Wayland R. Swain** has made six trips to the Soviet Union. These overseas visits have enabled Swain, a specialist in the ecosystems of the Great Lakes, to examine at firsthand what he estimates to be about 85 to 90 percent of the surface water in North America and Russia. His interest in freshwater bodies began in 1961 when he was a graduate student at the University of Minnesota and "discovered" large lakes in the literature of the required reading. His 1979 visit to Lake Baikal "fulfilled a nearly twenty-year-old dream," he says.

Although he works at the Environmental Protection Agency, the article in this issue of *Natural History* was written by Swain in his private capacity. No official support or endorsement by the Environmental Protection Agency or any other agency of the federal government is intended or should be inferred.

Earthquakes in the central and eastern United States are the professional concern of research geophysicist **Robert M. Hamilton**. A native of Texas who earned his Ph.D. in California but now lives in and likes the East, Hamilton is chief of the Office of Earthquake Studies of the U.S. Geological Sur-

tematically through time-lapse photography and other kinds of film research, note taking, and hours of observation. Just how city outdoor spaces work or fail to work is described in his book *The Social Life of Small Urban Spaces*, from which this article has been adapted. Mr. Whyte, a former editor of *Fortune* magazine, is the author of *The Organization Man* and *The Last Landscape*.



vey in Reston, Virginia. Research on the cause of earthquakes has taken him on field trips to New Zealand, southern California, Nevada, and Kenya. Projected research projects involve investigating the relation of earthquakes to the deep structure of the earth's crust.

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# The Piltdown Conspiracy

*A famous priest apparently was involved in the most spectacular scientific fraud of this century*

**by Stephen Jay Gould**

### Introduction and Background

*Of Conspiracies*

In his great aria "La calunnia," Don Basilio, the music master of Rossini's *Barber of Seville*, graphically describes how evil whispers grow, with appropriate watering, into truly grand and injurious calumnies. For the less conniving among us, the same lesson may be read with opposite intent: in adversity, try to contain. The desire to pin evil deeds upon a single soul acting alone reflects this strategy; conspiracy theories have a terrible tendency to ramify like Basilio's whispers until the runaway solution to "whodunit" becomes "everybodydunit." But conspiracies do occur. Even the pros and pols now doubt that Lee Harvey Oswald acted alone; and everybody did do it on the Orient Express.

The Piltdown case, surely the most famous and spectacular fraud of twentieth-century science, has experienced this tension ever since its exposé in 1953. The semiofficial, contained version holds that Charles Dawson, the lawyer and amateur archeologist who "found" the first specimens, devised and executed the entire plot himself. Since J.S. Weiner's elegant case virtually precludes Dawson's innocence (*The Piltdown Forgery*, Oxford University Press, 1955), conspiracies become the only reasonable refuge for challengers. And proposals for coconspirators abound, ranging from the great anatomist Grafton Elliot Smith to W.J. Sollas, professor of geology at Oxford. I regard these claims as farfetched and devoid of reasonable evidence. But I do believe that a conspiracy existed at Piltdown and that, for once, the most interesting hypothesis is actually true. I believe that a man who later became one of the world's most famous theologians, a cult figure for many years after his death in 1955, knew what Dawson was doing and probably helped in no small way—the French Jesuit priest and paleontologist Pierre Teilhard de Chardin.

*Teilhard and Piltdown*

Teilhard, born in Auvergne (central France) in 1881, belonged to an old, conservative, and prosperous family. Entering the Society of Jesus in 1902, he studied on the English island of Jersey from 1902 to 1905 and then spent three years as a teacher of physics and chemistry at a Jesuit school in Cairo. In 1908, he returned to finish his theological training at the Jesuit seminary of Ore Place in Hastings, providentially located right next to Piltdown on England's southeast coast. Here he stayed for four years, and here he was ordained a priest in 1912. As a theological student, Teilhard was talented enough, but lackadaisical. His passion at Hastings was, as it always had been, natural history. He scoured the countryside for butterflies, birds, and fossils. And, in 1909, he met Charles Dawson at the focus of their common interests—in a stone quarry, hunting for fossils. The two men became good friends and colleagues in pursuit of their interest. Teilhard described Dawson to his parents as "my correspondent in geology."

Dawson claimed that he had recovered the first fragment of Piltdown's skull in 1908, after workmen at a gravel pit told him of a "coconut" (the entire skull) they had unearthed and smashed at the site. Dawson kept poking about, collecting a few more skull pieces and some fragments of other fossil mammals. He did not bring his specimens to Arthur Smith Woodward, keeper of paleontology at the British Museum, until the middle of 1912. Thus, for three years before any professional ever heard of the Piltdown material, Dawson and Teilhard were companions in natural history in the environs of Piltdown.

Smith Woodward was not a secretive man, but he knew the value of what Dawson had brought and the envy it might inspire. He clamped a tight lid upon Dawson's information prior to its publication. He wanted none of Dawson's lay friends at the site, and only one naturalist accompanied Dawson and Smith Woodward in their first joint excavations at Piltdown—Teilhard de Chardin, whom Dawson had described as "quite safe." More specimens came to light during 1912, including the famous jaw with its two molar teeth, artificially filed to simulate human patterns of wear. In December, Smith Woodward published and the controversy began.

The skull fragments, although remarkably thick, could not be distinguished from those of modern humans. The jaw, on the other hand, except for the wear of its teeth, loudly said "chimpanzee" to many experts (in fact, it once belonged to an orangutan). No one smelled fraud, but many professionals felt that parts of two

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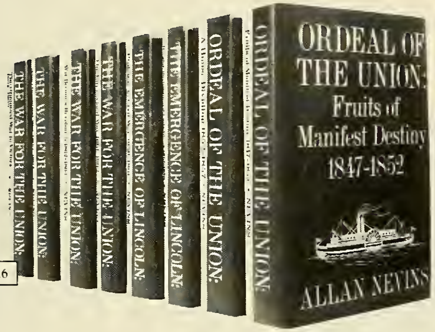

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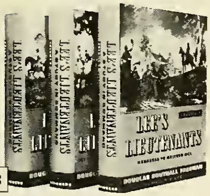

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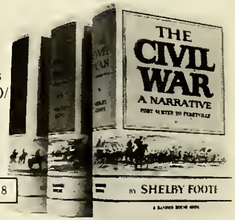

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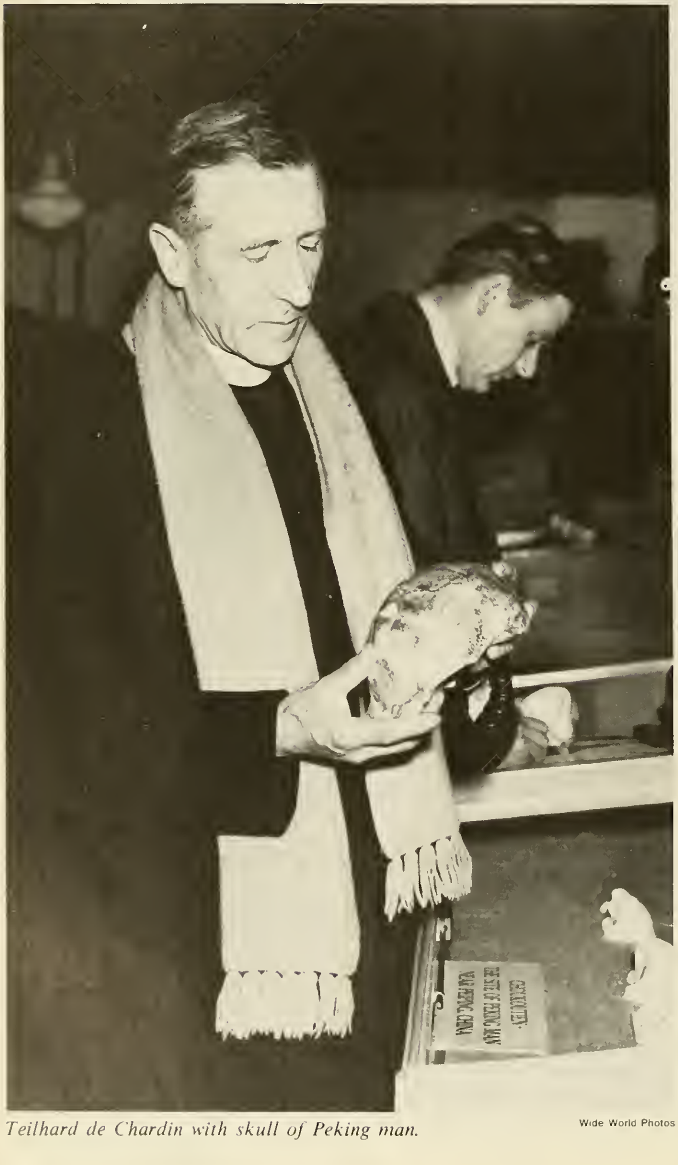
creatures had been mixed together at the Piltdown site. Smith Woodward stoutly defended the integrity of his creature, arguing, with flawed logic, that the crucial role of brain power in our mastery of the earth today implies a precocious role for large brains in evolutionary history as well. A fully vaulted skull still attached to an apish jaw vindicated such a brain-centered view of human evolution.

Teilhard left England late in 1912 to begin his graduate studies with Marcellin Boule, the greatest physical anthropologist of France. But in August 1913, he was back in England for a retreat at Ore Place. He also spent several days prospecting with Dawson and on August 30 made a major discovery himself—a canine tooth of the lower jaw, apish in appearance but worn in a human fashion. Smith Woodward continued his series of publications on the new material, but critics persisted in their belief that Piltdown man represented two animals improperly united.



*Teilhard de Chardin with skull of Peking man.*

Wide World Photos

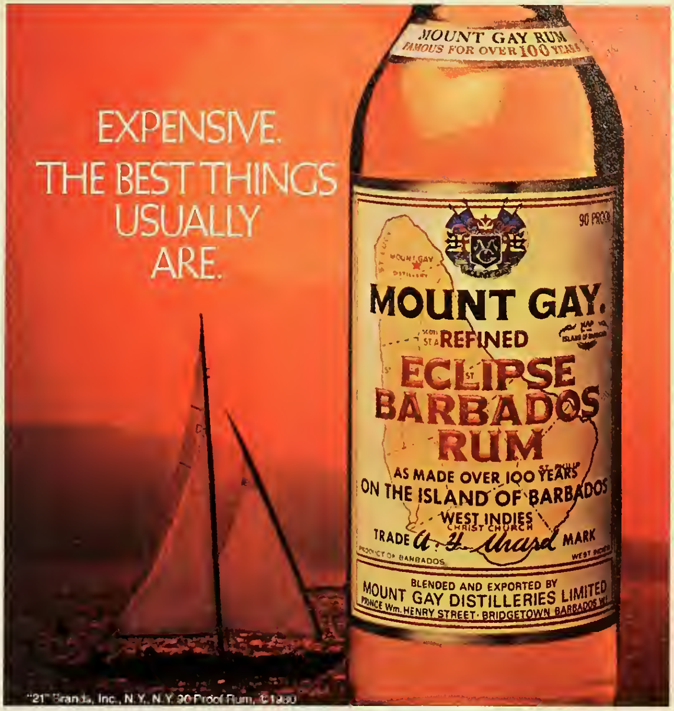
The impasse broke in Smith Woodward's favor in 1915. Dawson had been prospecting at another site, two miles from Piltdown, for several years. He probably took Teilhard there in 1913; we know that he searched the area several times with Smith Woodward in 1914. Then, in January 1915, he wrote to Smith Woodward. The second site, later called Piltdown 2, had yielded its reward: "I believe we are in luck again. I have got a fragment of the left side [it was actually the right] of a frontal bone with a portion of the orbit and root of nose." In July of the same year, he announced the discovery of a lower molar; again, apish in appearance but worn in a human fashion. The bones of a human and an ape might wash into the same gravel pit once, but the second, identical association of vaulted skull and apish jaw surely proved the integrity of a single bearer, despite the apparent anatomical incongruity. H.F. Osborn, America's leading paleontologist and critic of the first Piltdown find, announced a conversion in his usual grandiloquent fashion. Even Teilhard's teacher Marcellin Boule, leader of the doubters, grumbled that the new finds had tipped the balance, albeit slightly, in Smith Woodward's favor. Dawson did not live to enjoy his triumph, for he died in 1916. Smith Woodward stoutly supported Piltdown for the rest of his long life, devoting his last book (*The Earliest Englishman*, 1948) to its defense. He died, mercifully, before his bubble burst.

Meanwhile, Teilhard pursued his calling with mounting fame, frustration, and exhilaration. He served with distinction as a stretcher bearer in World War I and then became professor of geology at the Institut Catholique of Paris. But his unorthodox (although always pious) thinking soon led him into irrevocable conflict with ecclesiastical authority. Ordered to abandon his teaching post and to leave France, Teilhard departed for China in 1926. There he remained for most of his life, pursuing distinguished research in geology and paleontology and writing the philosophical treatises on cosmic history and the reconciliation of science with religion that later made him so famous. (They all remained unpublished, by ecclesiastical fiat, until his death.) Teilhard died in 1955, but his passing only marked the beginning of his meteoric rise to fame. His treatises, long suppressed, were published and quickly translated into all major languages. *The Phenomenon of Man* became a best seller throughout the world. Harvard's Widener Library now houses an entire tier of books devoted to Teilhard's writing and thinking. Two journals that were established to discuss his ideas still flourish.

Of the original trio—Dawson, Teilhard, and Smith Woodward—only Teilhard was still living when Kenneth Oakley, J.S. Weiner, and W.E. le Gros Clark proved that the Piltdown bones had been chemically stained to mimic great age, the teeth artificially filed to simulate human wear, the associated mammal remains all brought in from elsewhere, and the flint "implements" recently carved. The critics had been right all along, more right than they had dared to imagine. The skull bones did belong to a modern human, the jaw to an orangutan. As the shock of revelation gave way to the fascination of whodunit, suspicion quickly passed from two members of the trio. Smith Woodward had been too dedicated and too gullible; moreover, he knew nothing of the site before Dawson brought him the original bones in 1912. (I have no doubt whatsoever of Smith Woodward's total innocence.) Teilhard was too famous and too present for any but the most discreet probing. He was dismissed as a naïve, young student who, forty years before, had been duped and used by the crafty Dawson. Dawson acting alone became the official theory; professional science was embarrassed, but absolved.

*Doubts*

I was just the right age for primal fascination—twelve years old—and a budding paleontologist when news of the fraud appeared on page one of the *New York Times* one morning at breakfast. My interest has never abated, and I have, over the years, asked many senior paleontologists about Piltdown. I have also remarked, both with amusement and wonder, that very few believed the official tale of Dawson acting alone. I noted, in particular, that several of the men I most admire suspected Teilhard, not so much on the basis of hard evidence (for their suspicions rested on what I regard as a weak point among the arguments), but from an intuitive feeling about this man whom they knew well,



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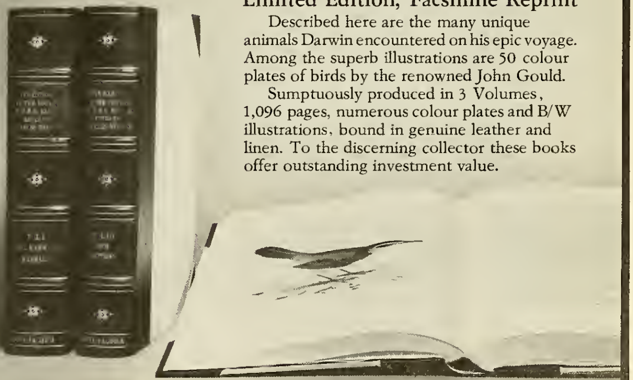

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*Pierre Teilhard de Chardin and Lucien Cuénot examine fossils from the Far East.*

loved, and respected, but who seemed to hide passion, mystery, and good humor behind a garb of piety. A.S. Romer and Bryan Patterson, two of America's leading vertebrate paleontologists and my former colleagues at Harvard, often voiced their suspicions to me. Louis Leakey voiced them in print, without naming the name, but with no ambiguity for anyone in the know (see his autobiography, *By the Evidence*).

I finally decided to get off my butt and probe a bit after I wrote a column on Piltdown for other reasons (*Natural History*, March 1979). I read all the official documents and concluded that nothing excluded Teilhard, although nothing beyond his presence at Piltdown from the start particularly implicated him either. I intended to drop the subject or to pass it along to someone with a greater zeal for investigative reporting. But at a conference in France last September, I happened to meet two of Teilhard's closest colleagues, the leading paleontologist J. Piveteau and the great zoologist P.P. Grassé. They greeted my suspicions with a blustering "*incroyable*." Then Père François Russo, Teilhard's friend and fellow Jesuit, heard of my inquiries and promised to send me a document that would prove Teilhard's innocence—a copy of the letter that Teilhard had written to Kenneth Oakley on November 28, 1953. I received this letter in printed French translation (Teilhard wrote it in English) in October 1979 and realized immediately that it contained an inconsistency (a slip on Teilhard's part) most easily resolved by the hypothesis of Teilhard's complicity. When I visited Oakley at Oxford in April 1980, he showed me the original letter along with several others that Teilhard had written to him. We studied the documents and discussed Piltdown for the better part of a day, and I left convinced that Romer, Patterson, and Leakey had been right. Oakley, who had noted the inconsistency but interpreted it differently, agreed with me and stated as we parted: "I think it's right that Teilhard was in it." (Let me here express my deep appreciation for Dr. Oakley's hospitality, his openness, and his simple, seemingly inexhaustible kindness and helpfulness. I always feel so exhilarated when I discover—and it is not so rare as many people imagine—that a great thinker is also an exemplary human being.) Since then, I have sharpened the basic arguments and read through Teilhard's published work, finding a pattern that seems hard to reconcile with his innocence. My case is, to be sure, circumstantial (as is the case against Dawson or anyone else), but I believe that the burden of proof must now rest with those who would hold Father Teilhard blameless.

## The Case Against Teilhard

*The Letters to Kenneth Oakley*

The main virtue of truth, quite apart from its ethical value (which I hold to be considerable), is that it represents an infallible guide for keeping your story straight. The problem with prevarication is that, when the going gets complex or the recollection misty, it becomes very difficult to remember all the details of your invented scheme. Richard Nixon finally succumbed on a minor matter, and Sir Walter Scott spoke truly when he wrote the famous couplet: "Oh, what a tangled web we weave,/When first we practice to deceive!"

Teilhard made just such a significant slip on a minor point in his letter to Oakley. Teilhard offered no spon-

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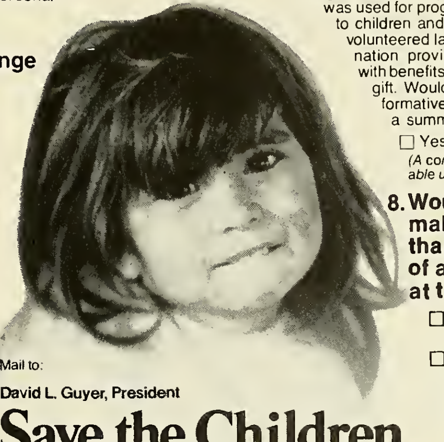

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taneous recollections about Piltdown and responded only to Oakley's direct inquiries for help in establishing the forger's identity. He begins by congratulating Oakley "most sincerely on your solution of the Piltdown problem. Anatomically speaking, *'Eoanthropus'* [Smith Woodward's name for the Piltdown animal] was a kind of monster. . . . Therefore I am fundamentally pleased by your conclusions, in spite of the fact that, sentimentally speaking, it spoils one of my brightest and earliest paleontological memories."

Teilhard then stonewalls on the question of fraud. He refuses to believe it at all, declaring that Smith Woodward and Dawson (and, by implication, himself) were not the kind of men who could conceivably do such a thing. Is it not possible, he asks, that some collector discarded the ape bones on a gravel pit that legitimately contained a human skull, the product of a recent interment. Could not the iron staining have been natural, since the local water "can stain (with iron) at a remarkable speed." But Teilhard's notion can explain neither the artificial filing of the teeth to simulate human wear nor the crucial discovery of a second combination of ape and human at the Piltdown 2 site. In fact, Teilhard admits: "The idea sounds fantastic. But, in my opinion, no more fantastic than to make Dawson the perpetrator of a hoax."

Teilhard then goes on to discuss Piltdown 2 and, in trying to exonerate Dawson, makes his fatal error. He writes:

> He Dawson just brought me to the site of Locality 2 and explained me [*sic*] that he had found the isolated molar and the small pieces of skull in the heaps of rubble and pebbles raked at the surface of the field.

But this cannot be. Teilhard did visit the second site with Dawson in 1913, but they did not find anything. Dawson "discovered" the skull bones at Piltdown 2 in January 1915, and the tooth not until July 1915. And now, the key point: Teilhard was mustered into the French army in December 1914 and was shipped immediately to the front, where he remained until the war ended. He could not have seen the remains of Piltdown 2 with Dawson, unless they had manufactured them together before he left (Dawson died in 1916).

Oakley caught the inconsistency im-

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mediately when he received Teilhard's letter in 1953, but he read it differently and for good reason. At that time, Oakley and his colleagues were just beginning their explorations into whodunit. They rightly suspected Dawson and had written to Teilhard to gather evidence. Oakley read Teilhard's statement when he was simply trying to establish the basic fact of Dawson's guilt. In that context, he assumed that Dawson had shown the specimens to Teilhard in 1913, but had withheld them from Smith Woodward until 1915—more evidence for Dawson's complicity.

Oakley wrote back immediately, and Teilhard, realizing that he had tripped, began to temporize. In his second letter of January 29, 1954, he tried to recoup:

> Concerning the point of "history" you ask me, my "souvenirs" are a little vague. Yet, by elimination (and since Dawson died *during* the First World War, if I am correct) my visit with Dawson to the *second* site (where the two small fragments of skull and the isolated molar were supposedly found in the rubble) must have been in late July 1913 [it was probably in early August].

Obviously troubled, he then penned the following postscript.

> When I visited the site no. 2 (in 1913?) the two small fragments of skull and tooth had already been found, I believe. But your very question makes me doubtful! Yes, I think definitely they *had* been already found: and that is the reason why Dawson pointed to me the little heaps of raked pebbles as the place of the "discovery."

In a final letter to Mable Kenward, daughter of the owner of Barkham Manor, site of the first Piltdown find, Teilhard drew back even further: "Dawson showed me the field where the second skull (fragments) were found. But, as I wrote to Oakley, I cannot remember whether it was after or before the find" (March 2, 1954).

I can devise only four interpretations for Teilhard's slip.

1. I thought initially, when I had only read the first letter, that one might interpret Teilhard's statement thus: Dawson took me to the site in 1913 and later stated in wartime correspondence that he had found the fragments in the rubble. But Teilhard's second letter states explicitly that Dawson, in the flesh, had pointed to the spot at Piltdown 2 where he had found the specimens.

2. Oakley's original hypothesis: Dawson showed the specimens to an innocent Teilhard in 1913, but withheld them from Smith Woodward until 1915. But Dawson would not blow his cover in such a crude way. For Dawson took Smith Woodward to the second site on several prospecting trips in 1914, always finding nothing. Now Teilhard and Smith Woodward were also fairly close. Dawson had introduced them in 1909 by sending to London some important mammal specimens (having nothing to do with Piltdown) that Teilhard had collected. Smith Woodward was delighted with Teilhard's work and praised him lav-

*Walking in the mud of the tropical forest along the Solo River, Java.*

Fondation Teilhard de Chardin

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ishly in a publication. He accepted Teilhard as the only other member of their initial collecting trips at Piltdown. Moreover, Teilhard was a house guest of the Smith Woodwards when he visited London in September 1913, following his discovery of the canine. If Dawson had shown Teilhard the Piltdown 2 finds in 1913, then led Smith Woodward extensively astray during several field trips in 1914, and if an innocent Teilhard had told Smith Woodward about the specimens (and I can't imagine why he would have held back), then Dawson would have been exposed.

3. Teilhard never did hear about the Piltdown 2 specimens from Dawson, but simply forgot forty years later that he had never actually viewed the fossils he had read about later. This is the only alternative (to Teilhard's complicity) that I view as at all plausible. Were the letters not filled with other damaging points, and the case against Teilhard not supported on other grounds, I would take this possibility more seriously.

4. Teilhard and Dawson planned the Piltdown 2 discovery before Teilhard left England. Forty years later, Teilhard misconstrued the exact chronology, forgot that he could not have seen the specimens when they were officially "found," and slipped in writing to Oakley.

Teilhard's letters to Oakley contain other curious statements, each insignificant (or subject to other interpretations) by itself, but forming in their ensemble a subtle attempt to direct suspicion away from himself.

1. In his letter of November 28, 1953, Teilhard states that he first met Dawson in 1911. In fact, they met in May 1909, for Teilhard describes the encounter in a vivid letter to his parents. Moreover, this meeting was an important event in Teilhard's career, for Dawson befriended the young priest and personally forged his path to professional notice and respect by sending some important specimens he had collected to Smith Woodward. When Smith Woodward described this material before the Geological Society of London in 1911, Dawson, in the discussion following Smith Woodward's talk, paid tribute to the "patient and skilled assistance" given to him by Teilhard since 1909. I don't regard this, in itself, as a particularly damning point. A first meeting in 1911 would still be early enough for complicity (Dawson "found" his first piece of the Piltdown skull in 1911, although he states that a workman had given him a fragment "several years before"), and I would never hold a mistake of two years against a man who tried to remember the event forty years later. Still, the later (and incorrect) date, right upon the heels of Dawson's first "find," certainly averts suspicion from Teilhard.

2. Oakley wrote again in February 1954, probing further into Dawson's first contact with the Piltdown material, wondering in particular what had happened in 1908. Teilhard simply replied (March 1, 1954): "In 1908 I did not know Dawson." True enough, but they met just a few months later, and Teilhard might have mentioned it. A small point, to be sure.

3. In the same letter, Teilhard tries further to avert suspicion by writing of his years at Hastings: "You know, at that time, I was a young student in theology—not allowed to leave much his cell of Ore Place (Hastings)." But this description of a young, pious, and restricted man stands in stark contrast with the picture that Teilhard painted of himself at the time in a remarkable series of letters to his parents (*Lettres de Hastings et de Paris 1908–1912*, Paris: Aubier, 1965). These letters speak little of theology, but they are filled with charming and detailed accounts of Teilhard's frequent wanderings all over southern England. Eleven letters refer to excursions with Dawson, and no other naturalist is mentioned so frequently. If he spent much time at Ore Place, he didn't choose to write about it. On August 13, 1910, for example, he exclaims: "I have travelled up and down the coast, to the left and right of Hastings; thanks to the cheap trains [*les cheap-trains* as he writes in French] so common at this time of year, it is easy to go far with minimal expense."

Perhaps I am now too blinded by my own attraction to the hypothesis of Teilhard's complicity. Perhaps all these points are minor and unrelated, testifying only to the faulty memory of an aging man. But they do form an undeniable pattern. Still, I would not now come forward with my case were it not for a second argument, more circumstantial to be sure, but somehow more compelling in its persistent pattern of forty years—the rec-

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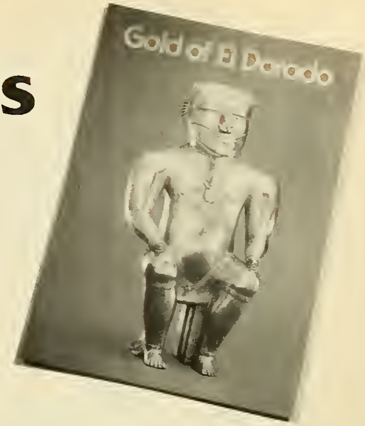

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ord of Teilhard's letters and publications.

*Piltdown in Teilhard's writing*

I remember a jokebook I had as a kid. The index listed "mule, sex life," but the indicated page was blank (ridiculous, in any case, for mules do not abstain just because the odd arrangement of their hybrid chromosomes debars them from bearing offspring). Teilhard's published record on Piltdown is almost equally blank. In 1920, he wrote one short article in French for a popular journal on *Le cas de l'homme de Piltdown.* After this, virtually all is silence. Piltdown never again received as much as a full sentence in all his published work (except once in a footnote). Teilhard mentioned Piltdown only when he could scarcely avoid it—in comprehensive review articles that discuss all outstanding human fossils. I can find fewer than half a dozen references in the twenty-three volumes of his complete works. In each case, Piltdown appears either as an item listed without comment in a footnote or as a point (also without comment) on a drawing of the human evolutionary tree or as a partial phrase within a sentence about Neanderthal man.*

Consider just how exceedingly curious this is. In his first letter to Oakley, Teilhard described his work at Piltdown as "one of my brightest and earliest paleontological memories." Why, then, such silence? Was Teilhard simply too diffident or saintly to toot his own trumpet? Scarcely, since no theme receives more voluminous attention, in scores of later articles, than his role in unearthing the legitimate Peking man in China.

As I began my investigation into this extraordinary silence, and trying to be as charitable as I could, I constructed two possible exonerating reasons for Teilhard's failure to discuss the major event of his paleontological youth. Kenneth Oakley then told me of the 1920 article, the only analysis of Piltdown that Teilhard ever published. I found a copy in the ten-volume edition of Teilhard's *oeuvre scientifique*, and realized that its content invalidated the only exculpatory arguments I could construct.

*The first argument:* Marcellin Boule, Teilhard's revered teacher, was a leading critic of Piltdown. He regarded it as a mixture of two creatures (not as a fraud), although he softened his opposition after he learned of the subsequent discovery at Piltdown 2. Perhaps Boule upbraided his young student for gullibility, and Teilhard, embarrassed to the quick, never spoke of the infernal creature, or of his role in discovering it, again.

The 1920 article invalidates such a conjecture, for in this work, Teilhard comes down squarely on the right side. He mentions that his English companions, convinced by finding the jaw so close to the skull fragments, never doubted the integrity of their fossil. Teilhard then notes, with keen insight, that experts who had not seen the specimens *in situ* would be swayed primarily by the formal anatomy of the bones themselves, and that these bones loudly proclaimed: human skull, ape's jaw. Which emphasis, then, shall prevail, geology or anatomy? Although he had witnessed the geology, Teilhard opted for anatomy:

> In order to admit such a combination of forms [a human skull and an ape's jaw in the same creature], it is necessary that we be forced to such a conclusion. Now this is not the case here. . . . The reasonable attitude is to grant primacy to the intrinsic morphological probability over the extrinsic probability of geological conditions. . . . We must suppose that the Piltdown skull and jaw belong to two different subjects.

Teilhard called it once, and he called it right. He had no reason to be embarrassed.

*The second argument:* Perhaps Teilhard had reveled in his role at Piltdown, cherished the memory, but simply found that the man he had helped to unearth could offer no support for, or even contact with, the concerns of his later career. On a broad level, this argument is implausible, if only because Teilhard wrote several general reviews about human fossils; however controversial or dubious, Piltdown should have been discussed. Even the leading doubters never failed to air their suspicions. Boule wrote chapters about Piltdown. Teilhard listed it without comment a few times and only when he had no choice.

In a more specific area, Teilhard's silence about Piltdown becomes inexplicable to the point of perversity (unless guilt and knowledge of fraud engendered it)—for Piltdown provided the best available support that fossils could provide for the most important argument of Teilhard's cosmic and mystical views about evolution, the dominant theme of his career and the source of his later fame. Teilhard never availed himself of his own best weapon, partly provided by his own hand.

The conclusion that skull and jaw belonged to different creatures did not destroy the scientific value of Piltdown, provided that both animals legitimately lay in the strata that supposedly entombed them. For these

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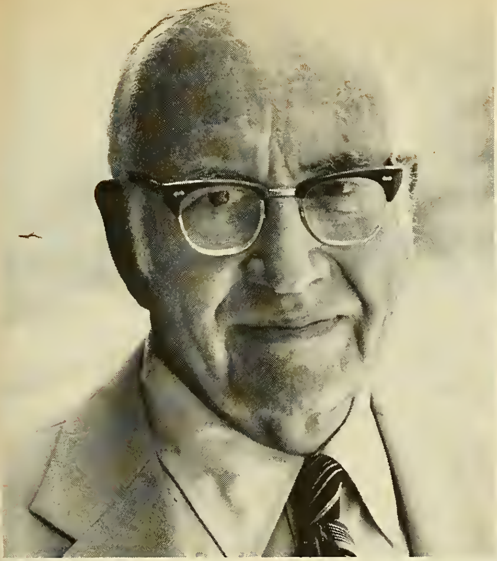
*Teilhard's complete works are spread over two editions—a thirteen-volume edited compendium of his general articles (Paris: Editions de Seuil), and a more extensive ten-volume facsimile reprint of his professional publications (Olten: Walter-Verlag). To my annoyance, I discovered that the Paris edition has expurgated all Piltdown references without so stating and without even inserting ellipses. In trying to spiff up Teilhard's record, they have made him appear even more culpable by accentuating the impression of guilty silence. I therefore consulted likely originals whenever I could find them. One expurgation is particularly infuriating in its downright misrepresentation. A posthumous volume of essays, *Le Coeur de la matière* ("The heart of matter," Seuil, 1976), reprints Teilhard's application for the chair of paleontology at the Collège de France in 1948 (ecclesiastical authority did not permit him to accept). In this autobiographical essay, Teilhard discusses his role in human paleontology: "My first stroke of good luck in this area of ancient human paleontology came in 1923 when I was able to establish, with Emile Licent, the existence, hitherto contested, of paleolithic man in Northern China." If Teilhard had thus truly suppressed Piltdown in presenting himself for review, what but complicity could we infer? By sheer good fortune, I found a copy of this unpublished, mimeographed document in the reprint collection of my late colleague A.S. Romer. It reads: "My first stroke of good luck in this area of ancient human paleontology was to be included, when still young, in the excavation of *Eoanthropus dawsoni* in England. The second was, in 1923, to be able to establish, with Emile Licent. . . ." I doubt that half a dozen copies of the unpublished original exist in America, and I might easily have been led from the published and doctored version to an even stronger indication of Teilhard's complicity based on his silence. (It has, of course, occurred to me that the pattern of silence I detect in Teilhard's writing might represent more his editor's posthumous expurgation than Teilhard's own preference. Yet the completely honest ten-volume facsimile edition contains more than enough material to establish the pattern, and I have checked enough original versions of potentially expurgated texts to be confident that references to Piltdown are fleeting and exceedingly sparse throughout Teilhard's writing.)



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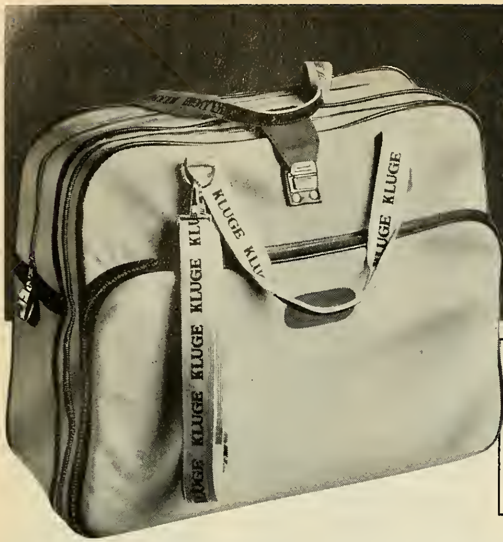

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strata were older than any housing Neanderthal man, Europe's major claim to anthropological fame. Neanderthal, although now generally considered as a race of our species, was a low-vaulted, beetle-browed fellow of decidedly "primitive" cast. Piltdown, despite the thickness of its skull bones, looked more modern in its globular vault. The assignment of the jaw to a fossil ape further enhanced the skull's advanced status. Humans of modern aspect must have lived in England even before Neanderthal man evolved on the continent. Neanderthal, therefore, cannot be an ancestral form; it must represent a side branch of the human tree. Human evolution is not a ladder but a series of lineages evolving along separate paths.

In the 1920 article, Teilhard presented the Piltdown skull, divorced from its jaw, in just that light—as proof that hominids evolved as a bundle of lineages moving in similar directions. He wrote:

> Above all, it is henceforth proved that even at this time [of Piltdown] a race of men existed, already included in our present human line, and very different from those that would become Neanderthal.... Thanks to the discovery of Mr. Dawson, the human race appears to us even more distinctly, in these ancient times, as formed of strongly differentiated bundles, already quite far from their point of divergence. For anyone who has an idea of paleontological realities, this light, tenuous as it appears, illuminates great depths.

To what profundity, then, did Teilhard refer Piltdown as evidence? Teilhard believed that evolution moved in an intrinsic direction representing the increasing domination of spirit over matter. Under the thrall of matter, lineages would diverge to become more unlike, but all would move upward in the same general direction. With man, evolution reached its crux. Spirit had begun its domination over matter, adding a new layer of thought—the noosphere—above the older biosphere. Divergence would be stemmed; indeed, convergence had already begun in the process of human socialization. Convergence will continue as spirit prevails. When the last vestiges of matter have been discarded, spirit will involute upon itself at a single point called Omega and identified with God—the mystical evolutionary apocalypse that secured Teilhard's fame.

But convergence is a thing of the future. Scientists seeking evidence for such a scheme must look to the past for twin signs of divergence accompanied by similar upward direction—in other words, for *multiple, parallel lineages* within larger groups.

I have read all of Teilhard's papers from the early 1920s. No theme receives more emphasis than the search for multiple, parallel lineages. In an article on fossil tarsiers, written in 1921, he argues that three separate primate lineages extend back to the dawn of the age of mammals, each evolving in the same direction of larger brains and smaller faces. In a review published in 1922 of Marcellin Boule's *Les Hommes fossiles*, Teilhard writes: "Evolution is no more to be represented in a few simple strokes for us than for other living things; but it resolves itself into innumerable lines which diverge at such length that they appear parallel." In a general essay on evolution, printed in 1921, he speaks continually of oriented evolution in multiple, parallel lines within mammals.

But where was Piltdown in this extended paean of praise for multiple, parallel lineages? Piltdown provided proof, the only available proof, of multiple, parallel lineages within human evolution itself—for its skull belonged to an advanced human older than primitive Neanderthal. Piltdown was the most sublime argument that Teilhard possessed, and he never breathed it again after the 1920 article.

These two arguments have been abstract. A third feature of the 1920 article is stunning in its directness. For I believe that Teilhard fleetingly tried to tell his colleagues, too subtly perhaps, that Piltdown was a phony. In discussing whether the Piltdown remains represent one or two animals, Teilhard laments that the direct and infallible test cannot be applied. One skull fragment contained a perfect glenoid fossa, the point of articulation for the upper jaw upon the lower. Yet the corresponding point of the lower jaw, the condyle, was missing on a specimen otherwise beautifully preserved at its posterior end. Teilhard writes: "Since the glenoid fossa exists in perfect state on the temporal bone, we could simply have tried to articulate the pieces, *if the mandible had preserved its condyle:* we could have learned, without possible doubt, if the two fit together." I read this statement in a drowsy state one morning at two o'clock, but the next line—set off by Teilhard as a paragraph in itself terminated by an exclamation point—destroyed any immediate thought of sleep: "As if on purpose [*comme par exprès*], the condyle is missing!"

*"Comme par exprès."* I couldn't get those words out of my mind for two days. Yes, it could be a literary line, a permissible metaphor for emphasis. But I think that Teilhard was trying to tell us something he didn't dare reveal directly.

*Other Arguments*

1. Teilhard's embarrassment at Oakley's disclosure. Kenneth Oakley told me that, although he had not implicated Teilhard in his thoughts, one aspect of Teilhard's reaction had always puzzled him. All other scientists, including those who had cause for the most profound embarrassment (like the aged Sir Arthur Keith, who had used Piltdown for forty years as the bedrock of his thought), expressed keen interest amidst their chagrin. They all congratulated Oakley spontaneously and thanked him for resolving an issue that had always been puzzling, even though the solution hurt so deeply. Teilhard said nothing. His congratulations arrived only when they could not be avoided–in the preface to a letter responding to Oakley's direct inquiries. When Teilhard visited London, Oakley tried to discuss Piltdown, but Teilhard always changed the subject. He took Teilhard to a special exhibit at the British Museum illustrating how the hoax had been uncovered. Teilhard glumly walked through as fast as he could, eyes averted, saying nothing. (A.S. Romer told me several years ago that he also tried to conduct Teilhard through the same exhibit, and with the same strange reaction.) Finally, Teilhard's secretary took Oakley aside and explained that Piltdown ws a sensitive subject with Father Teilhard.

But why? If he had been gulled by Dawson at the site, he had certainly recouped his pride. Smith Woodward had devoted his life to Dawson's concoction. Teilhard had written about it but once, called it as correctly as he could, and then shut up. Why be so embarrassed? Unless, of course, the embarrassment arose from guilt about another aspect of his silence—his inability to come clean while he watched men he loved and respected make fools of themselves, partly on his account. Marcellin Boule, his beloved master, for example, correctly called Smith

Woodward's *Eoanthropus* "an artificial and composite being" in the first edition of *Les Hommes fossiles* (1921). The skull, he said, could belong to *"un bourgeois de Londres"*; the jaw belonged to an ape. But he pondered the significance of Piltdown 2 and changed his mind in the second edition of 1923: "In the light of these new facts, I cannot be as sure as I was before. I recognize that the balance has now tipped a bit in the direction of Smith Woodward's hypothesis—and I am happy for this scientist whose knowledge and character I esteem equally." How did Teilhard feel as he watched his beloved master, Boule, falling into the abyss—when he contained tools for extraction that he could not use.

2. The elephant and the hippo. Bits and pieces of other fossil mammals were salted into the Piltdown gravels in order to set a geologic matrix for the human finds. All but two of these items could have been collected in England. But the hippo teeth, belonging to a distinctive dwarfed species, probably came from the Mediterranean island of Malta. The elephant tooth almost surely came from a distinctive spot at Ichkeul, Tunisia, for it is highly radioactive as a result of seepage from surrounding sediments rich in uranium oxide. This elephant species has been found in several other areas, but nowhere else in such highly radioactive sediments. Moreover, the Ichkeul site was only discovered by professionals in 1947; the doctored specimen at Piltdown could not have come from a cataloged museum collection.

Teilhard taught physics and chemistry at a Jesuit school in Cairo from 1905 to 1908, just before coming to Piltdown. His volume of *Letters from Egypt* again records little about theology and teaching, but much about travel, natural history, and collecting. He did not call at Tunisia or Malta on his passage down, but I can find no record of his passage back, and the two areas are right on his route from Cairo to France. In any case, Teilhard's letters from Cairo abound in tales of swapping and exchange with other natural historians of several North African nations. He was plugged into an amateur network of information and barter and might have received the teeth from a colleague.

This argument formed the base of evidence among my senior colleagues who suspected Teilhard—A.S. Romer, Bryan Patterson, and Louis Leakey (Leakey also mentioned Teilhard's knowledge of chemistry and the clever staining of the Piltdown bones). According to hearsay, le Gros Clark himself, a member of the trio that exposed the hoax, also suspected Teilhard on this basis. I regard this argument as suggestive, but not compelling. Dawson too was plugged into a network of amateur exchange.

3. Teilhard's good luck at Piltdown. Although records are frustratingly vague, I believe that all the Piltdown pieces were found by the original trio—Dawson, Smith Woodward, and Teilhard. (In the official version, a workman may have given Dawson the first piece in 1908.) Dawson, of course, unearthed most of the material himself. Smith Woodward, so far as I can tell, found only one cranial fragment. Teilhard, who spent less time at Piltdown than his two colleagues, was blessed. He found a fragment of the elephant tooth, a worked flint, and the famous canine.

People who have never collected in the field probably do not realize how difficult and chancy the operation is when fossils are sparse. There is no magic to it, just hard work. A tooth in a gravel pit is about as conspicuous as the proverbial needle in a haystack. The hoaxer worked hard on his Piltdown material. He filed the canine and painted it to simulate age. Apes' teeth are not easy to come by. If I had but one precious item, I would not stick it into a large gravel heap and then hope that some innocent companion would find it. It would probably be lost forever, not triumphantly recovered. I doubt that I would ever find it again myself, after someone else had mucked about extensively in the pile.

Teilhard described his discovery in the first letter to Oakley: "When I found the canine, it was so inconspicuous amidst the gravels which had been spread on the ground for sifting that it seems to me quite unlikely that the tooth could have been planted. I can even remember Sir Arthur congratulating me on the sharpness of my eyesight." Smith Woodward's recollection (from his last book of 1948) is more graphic:

> We were excavating a rather deep and hot trench in which Father Teilhard, in black clothing, was especially energetic; and, as we thought he seemed a little exhausted, we suggested that he should leave us to do the hard labor for a time while he had comparative rest in searching the rain-washed spread gravel. Very soon he exclaimed that he had picked up the missing canine tooth, but we were incredulous, and told him we had already seen several bits of ironstone, which looked like teeth, on the spot where he stood. He insisted, however, that he was not deceived, so we both left our digging to go and verify his discovery. There could be no doubt about it, and we all spent the rest of that day until dusk crawling over the gravel in the vain quest for more.

I also have some doubt about Teilhard's flint, for it is the only Piltdown item indubitably found *in situ*. All the other specimens either came from gravel heaps that had been dug up and spread upon the ground or cannot be surely traced. Now *in situ* can signify one of two things (and the records do not permit a distinction). It may mean that the gravel bed lay exposed in a ditch, cliff, or road cut—in which case, anyone might have stuck the flint in. But it may mean that Teilhard dug into the layer from undisturbed, overlying ground—in which case, he could only have planted the flint himself.

Again, I regard this argument only as suggestive, not as definitive. It is the weakest point of all, hence its place at the botton of my list. Perhaps Teilhard was simply a particularly keen observer.

### Conclusions

What shall we make of all this? I can only imagine three conclusions. First, perhaps Piltdown has simply deluded another gullible victim, this time myself. Maybe I have just encountered an incredible string of coincidences. Could all the slips in the letters have been innocent errors of an aging man; the *comme par exprès* merely a literary device; the failure to use his best argument a simple oversight; his conspicuous silence beyond a few fleeting and unavoidable mentions only an aspect of a complex personality that no one has fathomed; his profound embarrassment just another facet of the same personality; the elephant and hippo Dawson's property . . . ? I just can't believe it. Coincidences recede into improbability as more and more independent items coagulate to form a pattern. The mark of any good theory is that it makes coordinated sense of a string of observations otherwise independent and

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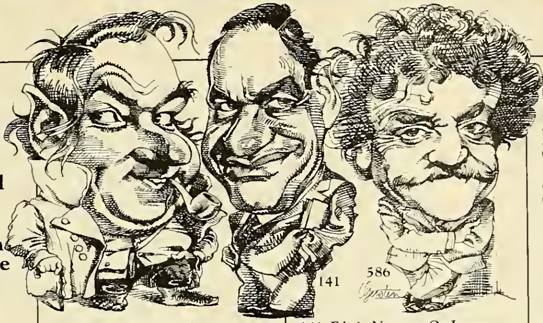

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inexplicable. Let us then assume that Teilhard knew Piltdown was a hoax, at least from 1920.

We are left with two possibilities. Was Teilhard innocent in the field at Piltdown? Did he tumble to the hoax later (perhaps when he deciphered the inconsistencies in Piltdown 2)? Did he then maintain silence out of loyalty to Dawson who had befriended him or because he didn't wish to stir a hornet's nest when he was not completely sure? But why, then, did he try so hard to exonerate Dawson in the letters to Oakley? For Dawson had used him and played on his youthful innocence as cruelly as he had deceived Smith Woodward. And why did he write a series of slips and half-truths to Oakley that embody, as their only pattern, an attempt to extract himself alone? And why such intense embarrassment and such conspicuous silence if he had guessed right but had been too unsure to say so?

Alan Ternes, editor of *Natural History*, made the interesting suggestion that Teilhard, as a priest, might have heard of the hoax through a confession by Dawson that he could not subsequently reveal. I have not been able to ascertain whether Dawson was Catholic; I do not think that he was. But I am told that priests may regard statements of contrition by other baptized Christians as privileged information. This is the most sensible version I have heard of the hypothesis that Teilhard knew about the fraud but did not participate in it. It would explain his silence, his embarrassment, even the "*comme par exprès*." But, in this case, why would Teilhard have tried to construct such an elaborate and farfetched theory of Dawson's innocence in his first letter to Oakley. Confession may have required silence, but surely not sheltering by falsehood. Any why the slips and half-truths for his own exoneration in the subsequent letters?

This leaves a third explanation—that Teilhard was an active coconspirator with Dawson at Piltdown. Only in this way can I make sense of the pattern in Teilhard's letters to Oakley, the 1920 article, the subsequent silence, the intense embarrassment.

This conclusion raises two final issues. First, to cycle back to my introduction, conspiracies have a tendency to spread. Once we admit Teilhard into the plot, should we not wonder about others as well? In fact, several knowledgeable people have strong suspicions about some young subordinates in the British Museum. I have confined my work to Teilhard's role; I think that others may have participated.

Second, what about motive? However overwhelming, the evidence cannot satisfy us without a reasonable explanation for why Teilhard might have done such a thing. Here I see no great problem, although we must recast Piltdown (at least from Teilhard's standpoint) as a joke that went too far, not as a malicious attempt to defraud.

Teilhard was not the dour ascetic or transported mystic that his publications sometimes suggest. He was a passionate man—a genuine hero in war, a true adventurer in the field, a man who loved life and people, who strove to experience the world in all its pleasures and pains. I assume that Piltdown was merely a delicious joke for him—at first. At Hastings, he was an amateur natural historian, with no expectation of a profesional career in paleontology. He probably shared the attitude toward professionals so common among his colleagues—there but for the vagaries of life go I. Why do they have the fame, the reputation, and the cash? Why do they sit at their desks and reap rewards while we, with deeper knowledge born of raw experience, amuse ourselves? Why not play a joke to see how far a gullible professional could be taken? And what a wonderful joke for a Frenchman, for England at the time boasted no human fossils at all, while France, with Neanderthal and Cro-Magnon, stood proudly as the queen of anthropology. What an irresistible idea—to salt English soil with this preposterous combination of a human skull and an ape's jaw and see what the pros could make of it.

But the joke quickly went sour. Smith Woodward tumbled too fast and too far. Teilhard was posted to Paris to become, after all, a *professional* paleontologist. The war broke out, and Teilhard had to leave just as the last act to quell skepticism, Piltdown 2, approached the stage. Then Dawson died in 1916, the war dragged on to 1918, and professional English paleontology fell further and further into the quagmire of acceptance. What could Teilhard say by the war's end? Dawson could not corroborate his story. The jobs and careers of other conspirators may have been on the line. Any admission on Teilhard's part would surely have wrecked irrevocably the professional career he had desired so greatly, dared so little to hope for, and at whose threshold he now stood with so much promise. What could he say beyond *comme par exprès*.

Shall we then blame Teilhard or shall we forgive him? We cannot simply laugh and forget. Piltdown absorbed the professional attention of many fine scientists. It led millions of people astray for forty years. It cast a false light upon the basic processes of human evolution. Careers are too short and time too precious to view so much waste with equanimity.

But who among us would or could have come clean in Teilhard's position? Unfortunately, intent does not always correlate with effect in our complicated world—yet I believe that we must judge a man primarily by intent. If Teilhard had acted for malice or in hope of reward, I would have no sympathy. But I cannot view his participation as more than an intended joke that unexpectedly turned to a galling bitterness almost beyond belief. I think that Teilhard suffered for Piltdown throughout his life. I believe that he must have cried inwardly as he watched Smith Woodward and even Boule himself make fools of themselves—the very men who had befriended and taught him. Could the anguish of Piltdown have been on his mind, when he made the following pledge from the trenches during World War I.

> I have come, these days, to realize one very elementary fact: that the best way to win some sort of recognition for my ideas would be for me myself to attain, in the truest possible sense of the word, to a "sanctity" that will be manifest to others—not only because of the particular force God would then give to whatever good is in my aspirations and influence—but also because nothing can give me more authority over men than for them to see me as someone who speaks to them from close to God. With God's help, I must live my "vision" fully, logically, and without deviation. There is nothing more infectious than the example of a life governed by conviction and principle. And now I feel sufficiently drawn to and sufficiently equipped for, such a life.

Teilhard paid his debt and lived a full life; may we all do so well.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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# Where Have All the Curlews Gone?

*One species seems to have gone extinct, although occasional sightings of the Eskimo curlew keep hopes alive*

**by Paul A. Johnsgard**

The morning of September 16, 1932, dawned gray and dismal, with a northeaster in full progress along the coast of Long Island. The night before, Robert Cushman Murphy, the noted authority on coastal and sea birds, and his family had camped near the lighthouse at the tip of Montauk Point. Shortly after daylight four large shorebirds headed in from the direction of the sea and dropped into the vegetation of a hillock near Murphy's tent. Stalking the birds, Murphy could scarcely believe his eyes. They were almost certainly Eskimo curlews, a species believed by some to be extinct, and had probably come from the coast of Labrador, where a curlew had been shot two weeks previously near the Strait of Belle Isle. So far as is known, that was the last Eskimo curlew ever shot on the North American continent, and Murphy's observation was to be the last along the Atlantic coast for nearly thirty years.

Those four remnant birds were following one of the most remarkable migration patterns of all the North American shorebirds. They were representatives of a species once so abundant that flocks on the Labrador coast were reported to be a mile long and nearly as wide. The calls of a distant flock were said to sound like the wind whistling through a ship's rigging or the jingling of countless sleigh bells. When the birds arrived from central Canada in August, they gorged themselves on the abundant invertebrates and crowberries of the Labrador coast in preparation for the long overseas flight to their wintering areas. If the fall weather was favorable, the birds remained in Newfoundland and Nova Scotia until early September, when they would leave for a nonstop flight to the Lesser Antilles, some 2,000 miles to the south. After a brief layover in the Lesser Antilles, the birds continued south over eastern Brazil and on to Argentina. The majority arrived at their winter quarters by mid-September, concentrating in the grassy pampas south of Buenos Aires.

However, fall storms on the Atlantic coast often affected this schedule and itinerary, forcing the birds to hug the North American shoreline. Large flocks would build up along the Atlantic coast, particularly in Massachusetts, on Long Island, and down through the Middle Atlantic and southern states. (Local hunters in New England called the curlews "doughbirds," apparently because they were so fat and tender.) Under adverse weather conditions, some flocks sought refuge on Bermuda. Westerly winds sometimes drove them far out over the Atlantic, and on rare occasions they would touch down in the British Isles.

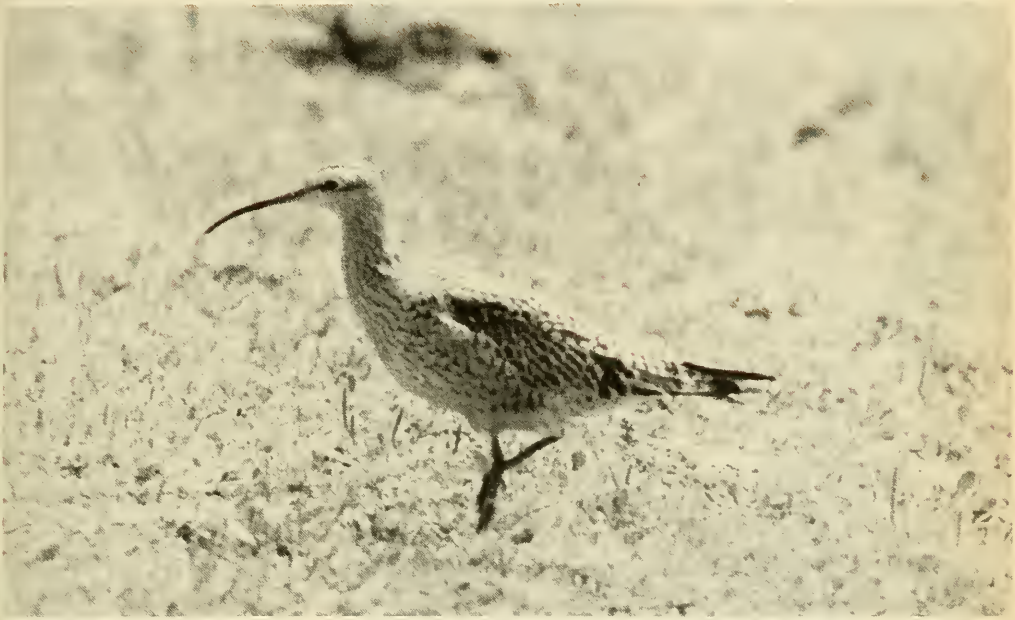
Such large assemblages of birds did not go unnoticed by hunters, who ruthlessly slaughtered thousands in Labrador every fall. The Hudson's Bay Company's store at Cartwright was a convenient place to sell the tasty birds, which were marketed in all eastern cities, and it was not unusual for twenty-five or thirty hunters to bring in as many as 2,000 curlews in a single day. Individual hunters often shot hundreds, usually by stationing themselves between feeding areas and simply waiting for the birds to pass by. The curlews' favored foraging areas were muddy tidal flats where small mollusks were abundant; these, together with crowberries, seem to have been the bulk of their autumnal foods. The birds were so intent on reaching the tidal flats that they continued to circle even when subjected to steady gunfire.

Such slaughter could not go on indefinitely. Between 1870 and 1880 the birds began to diminish rapidly, and by 1890 they had been practically exterminated on the Labrador coast. In that same year, however, a "cloud" of these curlews was observed on the Magdalen Islands in the Gulf of Saint Lawrence, the last sighting of a large flock anywhere. By 1900 the birds were nearly gone. An ornithologist who visited the Labrador coast in the fall of that year saw only five birds there and could find evidence for only about twelve for the entire area. Eight were seen in the fall of 1912 on the Labrador coast, of which all but one were shot.

Fall hunting was not the only hazard for the birds. Those that survived the long fall migration were also hunted without restriction in the South American wintering areas, although the intensity of hunting there was not nearly so great as in North America.

The Eskimo curlew's traditional spring migration route was quite different from the fall pattern. By late February or early March the birds left their wintering areas and probably undertook a nonstop flight to the Gulf Coast of the United States. They initially concentrated in the coastal prairies of Texas and Louisiana in early or mid-March and gradually moved northward through the southern Great Plains. They began arriving in Oklahoma in late March, and by early April they were abundant in Kansas, western Missouri, western Iowa, and Nebraska, as well as Oklahoma. These great spring flocks reminded the pioneers of passenger pigeons, and the birds were often called "prairie pigeons." They foraged and migrated in vast flocks; in flight these might reach a half mile in length and a hundred yards or more in width. When feeding in fields they frequently covered areas of forty to fifty acres. The largest flocks assembled during the period of corn planting, when the birds settled on newly plowed fields or burned-off prairie searching for grasshopper eggs, young grasshoppers, and other insects.

Market hunters from such cities as Saint Louis, Kansas City, and Omaha ravaged these flocks without mercy. Wagons brought from Omaha were literally filled with curlews. When they were shot for sport, the birds were simply dumped wholesale on the prairie, their bodies forming heaps as large as several tons of coal. Here, too, the birds circled in masses so dense that one "could scarcely throw


Don Bleitz

a brick or other missile into it without striking a bird," according to Myron Swenk, summarizing the species' decline in the Smithsonian Institution's Annual Report for 1915.

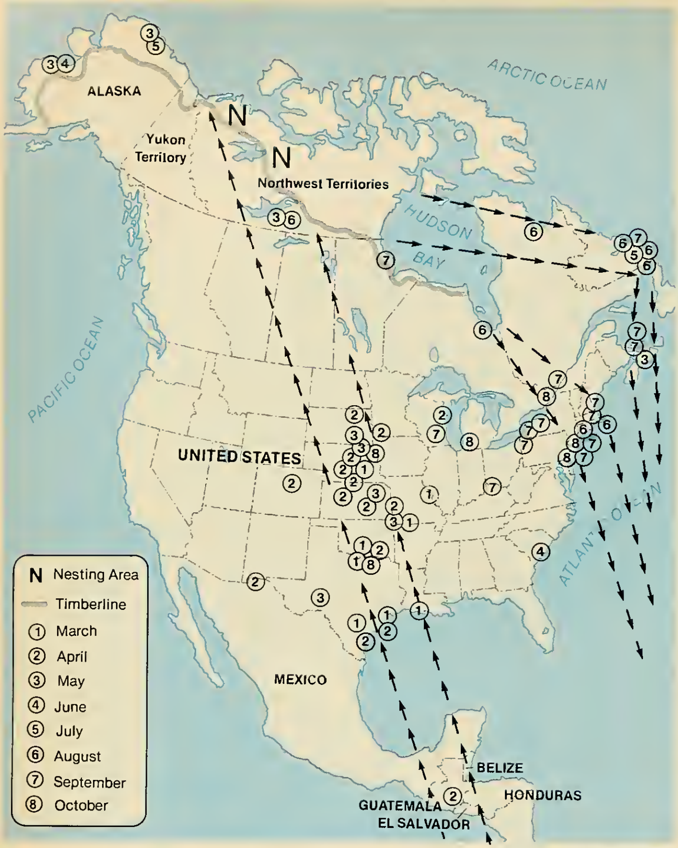
By mid-May, the birds were moving out of Nebraska and into eastern South Dakota and adjacent southwestern Minnesota. Nebraska seems to have been their last major spring staging area, for sighting records diminish progressively from South Dakota northward. There is no evidence of the birds stopping in North Dakota or in the Prairie Provinces of Canada. Instead, they apparently left eastern South Dakota in mid-May, made an almost nonstop flight to the Northwest Territories, and reached the vicinity of Great Slave Lake in the latter part of May.

Almost certainly the birds began to spread out widely once they reached the arctic tundra. There is no firm evidence that they nested in Alaska, but small curlews were seen in the late 1800s at Saint Michael and Cape Lisbourne in middle to late May, and very probably bred near Point Barrow since they were reported there between May 20 and July 6 of 1882, a period encompassing the nesting season.

The few actual records of nests include a clutch of three eggs hatching at Point Lake, Mackenzie, found in mid-June of 1822, and about thirty clutches located near Fort Anderson in northern Mackenzie by R. MacFarlane in mid-June of 1863 and 1864. The nests were well hidden in open tundra, and the clutch, like that of most shorebirds, consisted of four eggs. The incubation period was probably about four weeks, like that of other curlews, and hatching was reported as early as July 12. Another four weeks was probably needed for the young birds to fledge. By the middle of August the birds were ready to begin their fall migration. The majority of the birds, presumably the adults, evidently flew eastward across the northern part of Hudson Bay, thus making a direct line for the Labrador coast. A few early-arriving birds that reached Labrador by the middle of August were probably unsuccessful breeders. There was apparently a second migration route down the west coast of Hudson Bay that reached the Atlantic coast via Ontario and the Great Lakes. A few birds also moved southward through the Great Plains, essentially retracing the spring migration route. As in the golden plover, which has a similar migration route, these may have been young birds. The few fall records for Nebraska suggest that Eskimo curlews passed through the state in October. One bird shot in Nebraska at that time had a total of thirty-one grasshoppers in its stomach, as well as numerous small berries.

By 1900, sightings of Eskimo curlews had become so rare that they

Probable Migration Corridors of the Eskimo Curlew



Joe LeMonnier

can almost be individually noted. In Nebraska the last large flock (seventy to seventy-five birds) was observed in Merrick County in April 1900, while other, smaller numbers were seen in York County in 1904 or 1905, and in Madison County in 1909 or 1910. Among the last birds shot were seven (out of a flock of eight) killed in April 1911 in Merrick County, Nebraska. In September 1913 a single bird was shot in Massachusetts. Finally, a lone bird was killed on April 17, 1915, near Norfolk, Nebraska, just a year prior to the signing of the Migratory Bird Treaty, designed to protect and control the hunting of migrating birds. So far as anyone knows, it was the last curlew to be killed in Nebraska, although a group of eight was reported seen near Hastings on April 8, 1926. In 1924 a small flock was seen near Buenos Aires, Argentina, and one was collected; the next year a single bird was shot in the same location. In 1929 one was killed in Maine. A collector for museums shot one bird in Labrador in 1926, four in 1927, and one in 1932—the year Murphy saw the four on Long Island. In 1945 two were reportedly seen in late April on Galveston Island, Texas, and another was reported in mid-July 1956 on Folly Island off the South Carolina coast, a rather unlikely time and location. In June 1946, however, there was another sighting on the South Carolina coastline, and in April 1950 a reliable observer near Rockport, Texas, reported seeing a single bird. In September 1964 a specimen was killed on Barbados. Each new record raised hopes for the species, together with fears that the very last bird had just been seen or killed.

The 1945 Galveston Island sighting had been virtually forgotten by 1959, when on March 22 two bird watchers there saw a small, strange-looking curlew feeding among a group of long-billed curlews. After tentatively identifying it as an Eskimo curlew, they returned with a professional ornithologist, G. H. Williams, who confirmed their identification.

The bird was seen by numerous other observers until April 12, and during the following year a bird was again observed in the same field. In 1961 perhaps the same bird was observed and successfully photographed, and in 1962 the exciting discovery was made that at least three and possibly four curlews were present on Galveston Island.

These Texas sightings added considerably to the hopes that a breeding population might still exist. Countering this optimism was the possibility that at least some of the birds seen may have been the Asian little curlew, a very closely related form (some ornithologists suggest it is a different race of the same species) that breeds in eastern Siberia and normally winters in Australia. But since many of the recent sightings were from the Atlantic rather than the Pacific coast, and were mostly within the traditional migratory corridors of the Eskimo curlew, these suspicions do not appear to have great merit. Nevertheless, the early sightings of possible breeding birds in western Alaska may indeed have been of the Asian species rather than of the Eskimo curlew.

There were few sightings in the period between 1965 and the present. In late August 1970, a single bird was reported by two observers at Plymouth Beach, Massachusetts. In early August 1972, two birds were observed closely on Martha's Vineyard, Massachusetts. In mid-August 1976, a pair of probable Eskimo curlews were seen flying over an area of coastal tundra along the west coast of James Bay by two experienced ornithologists, one of whom had earlier observed the species at Galveston Island. Thus, as recently as four years ago there was some evidence that this species, believed by some to be extinct by 1920, probably still existed. All told, between 1932 and 1976 there have been at least six sightings of the Eskimo curlew on the coast of Texas, seven from the Atlantic coast, and one from James Bay.

Now, after a period of limited optimism, ornithologists are again in a state of uncertainty and doubt as to the existence of this elusive bird. In spite of the ever increasing activities of bird watchers, no sightings have been reported from the Texas coast in the last decade, and the present status of this ill-fated bird is impossible to judge. Most of the persons who have summarized its sad story have come to the conclusion that uncontrolled hunting, particularly spring hunting in the Great Plains, was the single most important factor in its demise. Richard C. Banks of the U.S. National Museum has recently reviewed the history of the species' decline, and although he agrees that hunter overkill was doubtless an important factor, he suggests it may not have been the only one. Several climatic factors, including an increase in fall storms along the North Atlantic coast and possibly lowered reproductive success on arctic nesting grounds in the late 1880s during a period of unusually cool summers, could also have contributed to increased mortality and lowered reproductive rates. These speculations are interesting but inconclusive, and we are left in doubt about what, if anything, can be done to protect and preserve a species that at best seems nearly mythical and at worst may already be extinct.

There must have been a majesty to the swirling flocks of Eskimo curlews as they swept across the Great Plains or down the Labrador coast. In perpetuating their memory, one can do no better than to quote an early observer, Lucien M. Turner, who saw a flock of several hundred birds flying south along the Ungava coast of northern Labrador in September 1884.

> They flew in that peculiar manner which distinguishes the curlews from all other birds in flight, a sort of wedge shape, the sides of which were constantly swaying back and forth like a cloud of smoke wafted by the lightest zephyr. The aerial evolutions of the curlews when migrating are, perhaps, one of the most wonderful in the flight of birds. Long, dangling lines either perpendicular or horizontal, the lower parts of which whirl, rise, or twist spirally, while the apex of the flock is seemingly at rest. At other times the leader plunges downward successively followed by the remainder in most graceful undulation, becoming a dense mass then separating into a thin sheet spread wide; again re-forming into such a variety of positions that no description would suffice.

The sight of these great shifting clouds, combined with the distant sound of avian sleigh bells tinkling or wind whistling through a ship's riggings, was a phenomenon that has vanished from the American scene. ☐

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# Beetles Adorned with Horns

*If these insects were any larger, they would be fearsome*

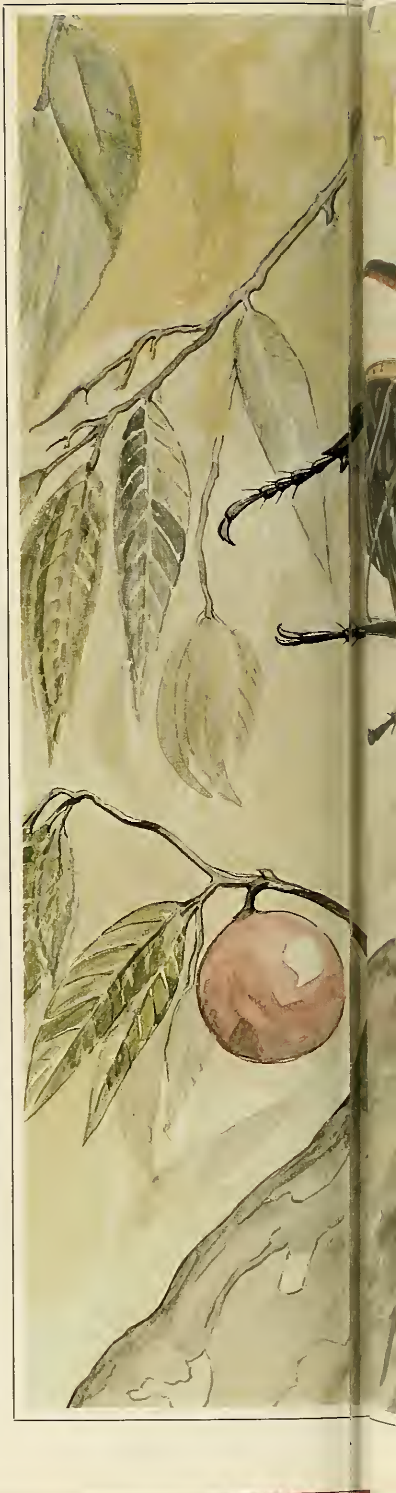
**Text and paintings by Daniel Otte**

Charles Darwin once said that if horned beetles were magnified to the size of a horse or even a dog, they would be the most imposing animals in the world. Some small boys believe that horned beetles are impressive even at their present size. In my school days in Zululand, South Africa, we dug beetles from burrows under cow dung in the summer, and the longer-horned varieties were especially prized, for they bestowed instant status. Evening preparation hours at our boarding school were made more instructive by testing the strength of beetles tethered to ink bottles, workbooks, and rulers; reputations were made and lost in matches between beetles. In Africa, where oxen are used for hauling and plowing, horned beetles are living toys and children use them to pull miniature sleds and wagons.

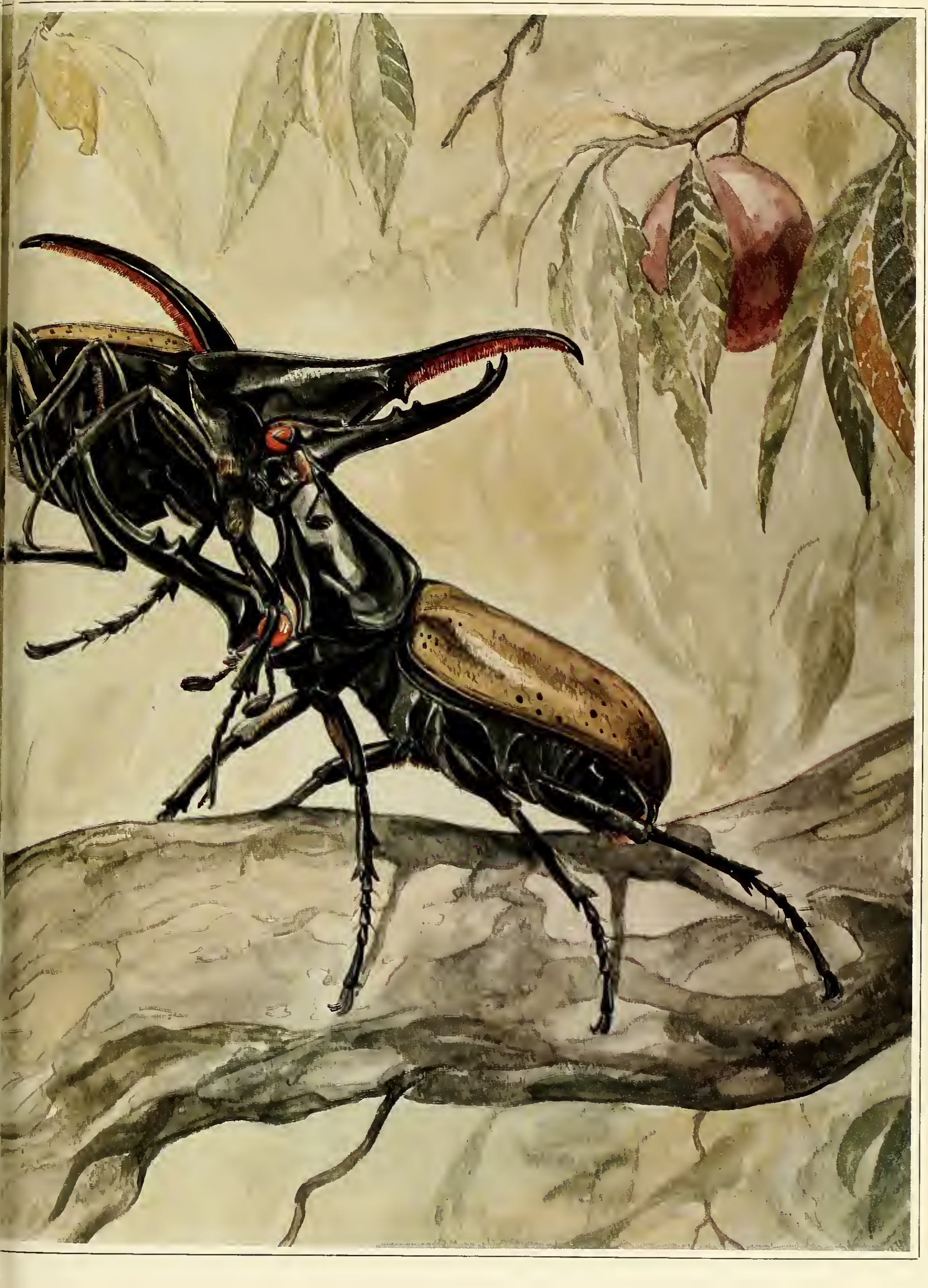
Most horned varieties belong to the Lamellicornia, a large group of beetles that includes two families: the scarabs, or chafers, and the stag beetles. Of the more than 20,000 described scarab species, most are hornless, but some scarab species develop horns that are hollow skeletal outgrowths of either the head or thorax and so are analogous to the bone and dermal outgrowths that give rise to horns in mammals and reptiles. The stag beetle family is much smaller in number of species but includes proportionately more horned varieties. Their horns are technically not horns at all but enlargements of the jaws, and they are therefore more closely analogous to mammal tusks or to enlarged bird beaks.

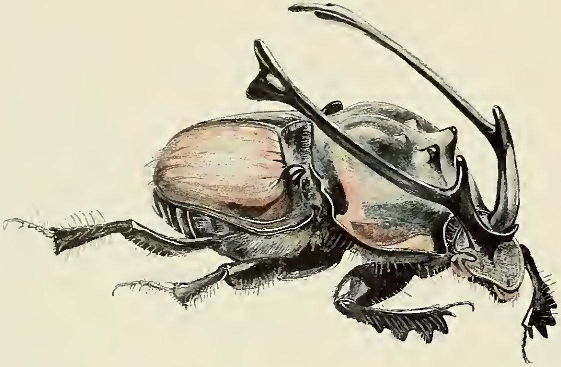
Beetle horns do not develop gradually, as in mammals, but are quickly and fully formed during the last molt to the adult stage. The final size of the horns is believed to depend on nutrition, with well-fed larvae giving rise to larger-horned adults than larvae that are poorly fed.

Early naturalists, most of them collectors, often had little time or inclination to observe the behavior of beetles in their natural habitats. Speculations on the use of horns were therefore based mainly upon examinations of pinned museum specimens or, only rarely, on observations of beetles in captivity. Some early naturalists speculated that horns were sometimes used in defense against predators, to dig burrows and bulldoze excavated material from rotting wood, as weapons in fights between males, and occasionally even to carry away a female. Darwin thought that horns might on occasion be used as ornaments to impress females, while other biologists speculated that horns could be used to lacerate stems or leaves and permit the beetles to feed on plant saps. Still another viewpoint, one held by Julian



*Two male scarab beetles battle over a favorable mating site. The victor is the one that can lift his opponent in the air and drop him to the ground.*





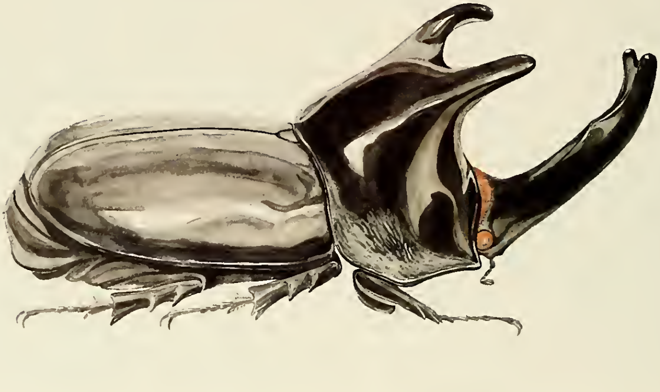
*A scarab beetle from Africa,* Onthophagus rangifer *inhabits dung heaps.*

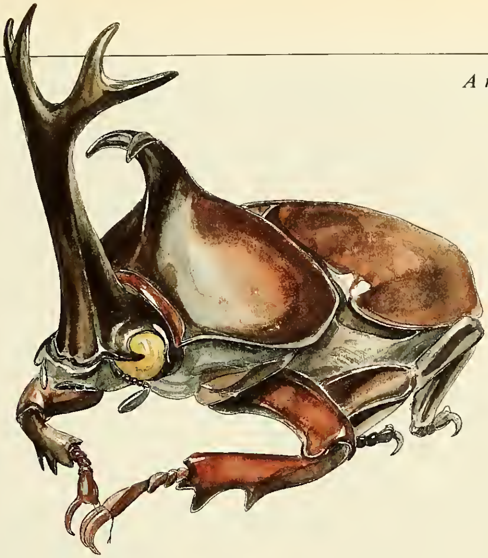
Huxley, was that horns served no function and were merely byproducts of increasing body size.

What conditions favor the evolution of horns? Gilbert Arrow, the British specialist on horned beetles, suggested that enlarged jaws are more likely to evolve in species that do not routinely use the mandibles in feeding. He reasoned that only short-lived species that feed on liquids or soft foods as adults would be free, so to speak, to evolve long mandibles. William Eberhard, who has been studying beetles in the field, has recently proposed that since many beetles live in relatively enclosed spaces, physical contests are more likely to be decided by strength in pushing matches than by speed or agility. Although the jaws were initially used in feeding and excavating, they could have been applied to biting opponents and then subsequently become enlarged.

The early stages in the development of fighting horns in scarabs are more difficult to envision. If evolutionary biologists are correct, complex anatomical features, such as horns, are acquired gradually by a series of small increments over hundreds of generations. Outgrowth horns might have begun as small bumps on the exoskeleton. For a bump to increase in size it must give its bearer some advantage over other members of the population. But could a small bump have been used as a weapon? Intuition tells one that the structure would have to reach

Megacerus jason *is a scarab with formidable pinching ability.*



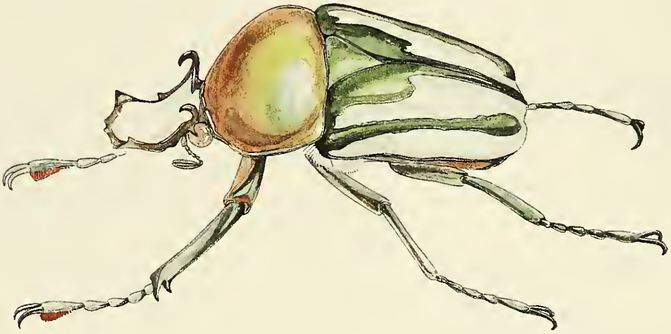


*A native of Japan,* Allomyrina dichotomus *sports horns that resemble deer antlers.*

some critical size before it could become effective (just as an adjustable wrench must be opened or closed to a critical point to be effective on a nut). One can surmise that outgrowth horns of scarabs evolved to an effective size for fighting only indirectly—perhaps the projections, or ridges, were initially used to move debris or dung, and that in such situations even the smallest changes in the exoskeleton could have made a difference to the animals bearing them and so could be modified by natural selection. Once they reached a certain critical size they could begin to act as weapons and be improved by a new set of selection pressures.

Among the horned beetles the mode of breeding seems to influence how similar the two sexes are to one another. In promiscuous species, those in which males mate with several females and take no part in assisting the female in rearing offspring, body size and horn differences between the sexes are pronounced. In monogamous species, in which the male mates with and assists a single female, the two sexes are often nearly identical in size and appearance. The few differences between monogamous mates are usually behavioral, associated with a well-defined division of labor. In the stag beetle *Sinodendron cylindricum,* for example, the mandibles do not differ in size or shape. The two sexes collaborate in preparing a burrow and provisioning it with food for the young.

Ranzania splendens *is a horned scarab that lives on foilage. Its horns can be used to scoop opponents off tree perches.*

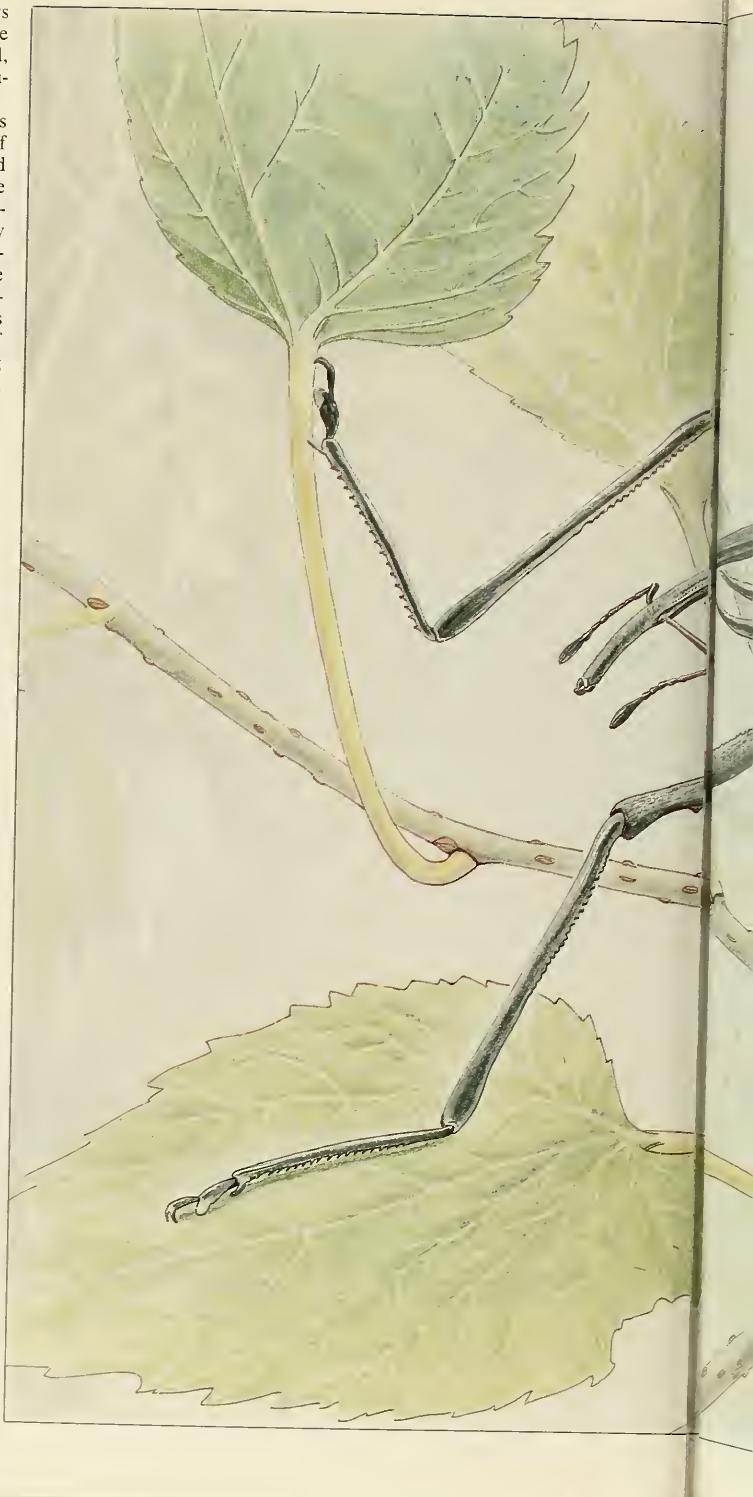


As a rule the female digs the burrows and prepares brood niches while the male travels backward and forward, sweeping and removing the accumulating debris.

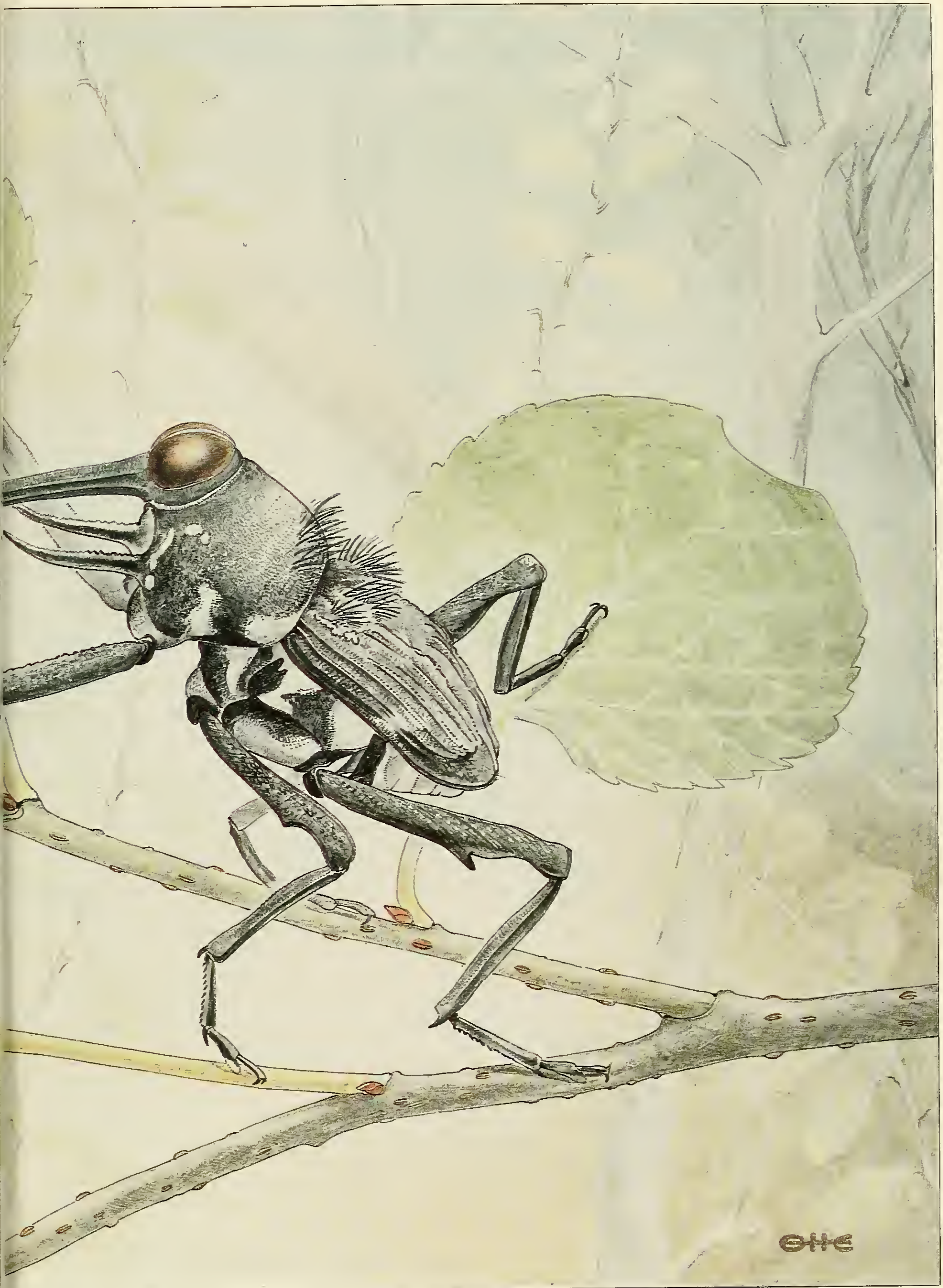
One commonly expressed notion is that beetle horns are the product of sexual selection, the force conceived by Charles Darwin to account for the striking structural and behavioral differences between the sexes of many species. As presently understood, sexual selection is usually viewed as the selective influence exerted by members of the same sex or by members of the opposite sex in the context of reproduction. Males can exert a strong selection pressure on their own sex if inherited differences cause some to win and others to lose in the competition to reproduce. Females can intensify this pressure by mating only with males victorious in battle or by favoring the most brightly colored or largest males available to them.

Females in at least one species of beetle seem to have a more than passing interest in the outcome of battles raging on their behalf. Darwin described how females of the stag beetle *Lethrus cephalotes* seemingly force males into combat and mate with the victor. "The two sexes inhabit the same burrow, and the male has larger mandibles than the female. If, during the breeding season, a strange male attempts to enter the burrow, he is attacked; the female does not remain passive, but closes the mouth of the burrow and encourages her mate by continuously pushing him on from behind; and the battle lasts until the intruder is killed or runs away." Mating with winners may have certain advantages. A female does not need the ability to judge the quality of a mate if males of higher quality tend to win, which they do, nor does she risk being deceived by male advertisement or propaganda.

Darwin knew that beetles occasionally used their horns in combat, but he suggested that the more spectacular varieties were perhaps ornamen-



*The two tusks behind the long snout and the spines on the hind legs suggest that fighting occurs among males of this species of* Mecopus. *This beetle is native to the Solomon Islands.*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tal and used principally to excite females. His judgment on the pinching powers of beetles was based, so far as we can tell, on his experiments with *Chiasognathus grantii*, a huge-jawed beetle from Chile. By placing his thumb between its horns, Darwin discovered that *C. grantii* could not hurt him. But *C. grantii* and its close relatives happen to be unusual among stag beetles in having exceptionally narrow heads, a feature that makes it difficult to exert much lateral pressure. Had Darwin experimented with a broad-headed species he might well have ended up with a punctured thumb and a different theory.

As the habits of more species are studied, the uses of horns are becoming clearer. Fighting has been seen in many species and *C. grantii* have been seen tearing one another apart. W. D. Hamilton, who has observed fighting in *C. grantii*, believes this species fights mainly in trees, where females may be attracted to sap flows or flowers; males perhaps wait here for females and fight among themselves to be the first to mate with any female that arrives. During these fights males try to lift one another into the air, and battles are won by the male who lifts his opponent and drops him to the ground. Not surprisingly, males with small horns lose to larger males.

Larger males within a beetle species have relatively larger horns than small males, and comparisons among species indicate that the largest horns, relative to body size, are found in the largest species—a relationship that is also known to occur among some lineages of deer. William Beebe saw this phenomenon in some South American beetles and called the larger-bodied, big-horned types *majors* and the smaller-bodied, smaller-horned individuals *minors*. When William Eberhard measured a large number of males of the scarab *Podischnus agenor* he found that horns fall into two distinct size classes. In species of stag beetles in which we have measured large numbers of males, large males and small males are revealed to be the ends of a continuous size distribution.

Why the larger individuals of a species possess relatively larger horns than smaller individuals is an unsolved problem. One hypothesis relates to the allocation of resources during development. Males that are relatively energy starved during maturation might be expected to avoid expenditures on horn development if a certain minimal horn or body size must be attained for them to be effective in fighting. Such males might rely instead on high dispersibility and increased longevity to augment their chances of finding and mating with females. But males with access to abundant resources during the larval stages might, after attaining the optimal body size, put all available energy into horns and their supportive structures. According to this hypothesis horns are a luxury that only males with access to large quantities of food can afford.

Male beetles employ different reproductive strategies. If mating investment is the energy that a male must expend to maximize the number of matings he achieves, at least two major evolutionary modes of investment are apparent: a male can emphasize the production of structures, such as horns and muscles, that give him strength and protect him from possible injury; or he can increase the chances of encountering unmated females by emerging first to the adult stage or by increasing his awareness of females and his quickness in reaching them. William Beebe observed how both modes may exist within a species of beetle. When he placed a small male of *Dynastes hercules* into a chamber with five large males and four females, the small male showed far greater vitality than any large one, mating with all the females in turn and several times in succession with two of them, while the larger beetles mated with only one or two. In combat the small male could not win; although he fought vigorously, he was invariably carried off the field held high in the air.

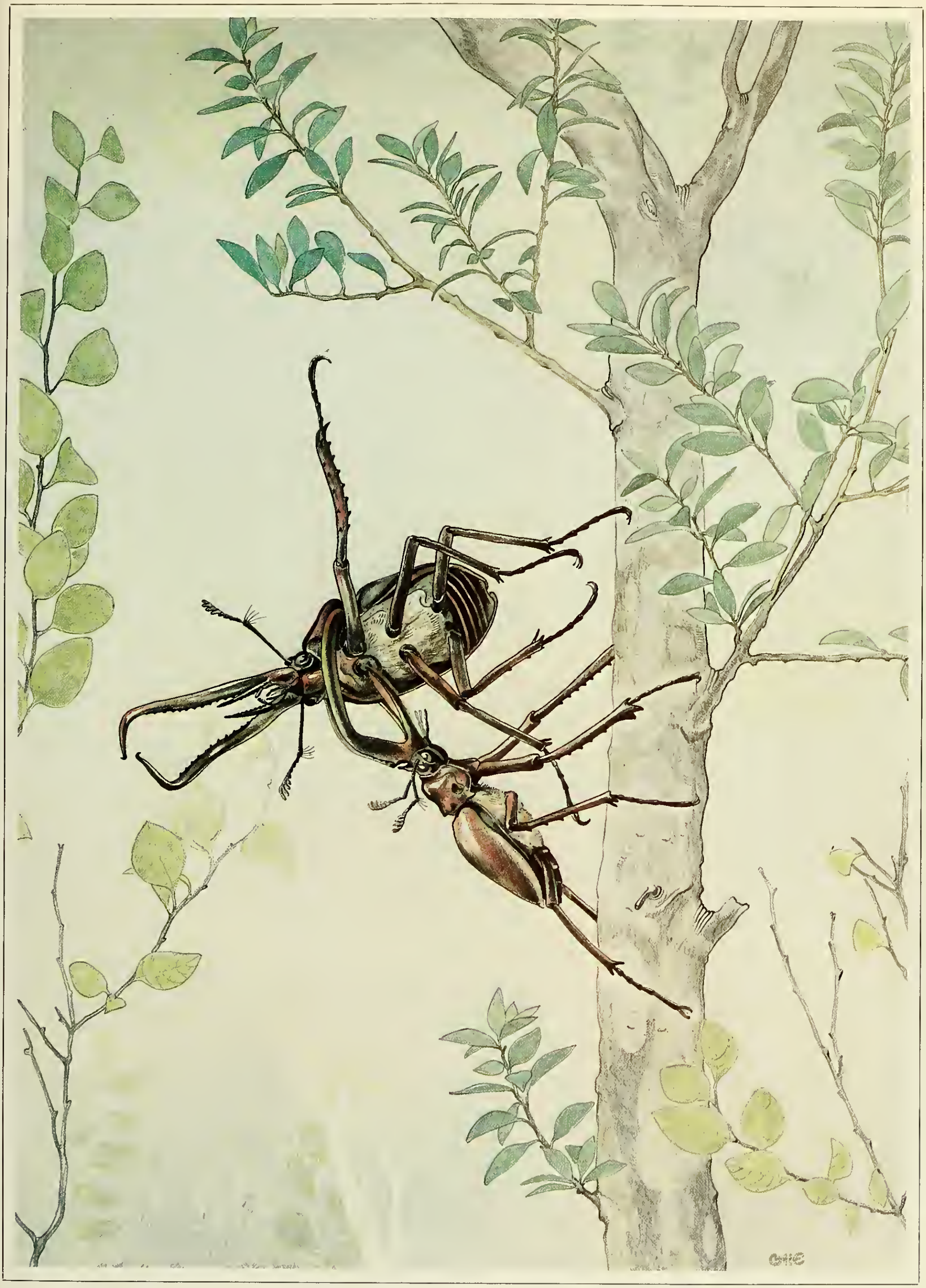
Fighting between insects is often not harmful because the contestants only exhibit behavioral displays that do no damage. Geoffrey Parker has argued that it is important for animals to know their relative strengths, and that ritualized fighting is a way for combatants to estimate their strength. Small or weak males may break off an encounter with larger or stronger males when the probability of a successful combat is low. After the initial bouts, large males may be encouraged to continue the fight because the resources can be gained with little extra effort. If the combatants can gauge their strengths in initial encounters, weaker individuals should give up and fights should not escalate.

In higher animals, strength seems to be determined visually and can be done at a distance—the contestants evaluate one another on the basis of body size and horn length, and fights seem to occur only among closely matched rivals. When animals merely estimate the prowess of rivals, the system is open to exploitation by bluffing. When males actually grapple with one another, the contestants can directly determine one another's strength. But when the assessment involves distance signaling, all a male needs to do is convince his rival that he is stronger, which he can do by posturing and through other forms of propaganda. Sir Ronald Fisher believed that males should, as a consequence, become less and less deceived by propaganda and be persuaded only by signals that indicate a genuine prowess.

Propaganda seems to be more prevalent in species that advertise their prowess through distance signaling than in species that must prove their ability. There is no evidence for the existence of power advertisements or propaganda in insects. They are probably forced to lead less deceitful lives because of their visual and sensory shortcomings. The assessment of strength requires contact, so they are more likely to determine real strength than are mammalian contestants who engage in much visual estimating. Because it is difficult for insects to signal their strength at a distance, fights between grossly mismatched males might be more common.

When horned beetles are observed more carefully under both natural and controlled conditions, we should learn more about how horns are used and which selection pressures directed their evolution. It should be especially interesting to know if countervailing selection pressures will result in different modes of competition among the members of a single population and to discover which differences within a species are due to genetic factors and which attributable mainly to developmental conditions. ☐

*Having lifted his opponent, a longer-horned male is in position to throw the smaller-horned beetle to the ground. This species of stag beetle,* Chiasognathus grantii, *is the one Darwin encountered in Chile.*



From *Maasai*. Text by Tepilit Ole Saitoti; photographs by Carol Beckwith.

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# Warriors of Maasailand

*Although a lion could run faster, we could run farther*

**by Tepilit Ole Saitoti**
**photographs by Carol Beckwith**

When circumcised Maasai youths enter warriorhood, at about sixteen years of age, they let their hair grow long and spend much time in grooming it. Everything they wear must be new, to symbolize a new life. They replace their old attire with togas dyed with red ocher. They also cover their bodies from head to toe with the same red ocher. Their parents give the warriors new long spears, and their mothers and girlfriends make all new beaded ornaments for them.

The youths begin to experience a freedom that they never had before as mere boys. They can now socialize with girls and have sex. They are free to roam Maasailand without asking their parents' permission. They have more control over their destiny and some degree of decision-making power. They can shake hands with other men as equals, instead of bending their heads in the respectful greeting of a child. And they attain the high degree of confidence that is known and enjoyed only by Maasai warriors after total manhood.

Young are the warriors, and we feed them the best of our meat. Healthy, they will protect our herds from enemies and famine. And they will stop all the foes of our people from encroaching upon us.

These words, sung by senior warriors to their younger comrades, express something of the significance and the almost magical powers attributed to the title *ilmoran* ("warriors") in Maasailand. Whenever there is

*Resplendent in ostrich-feather headdresses and special cloaks, warriors perform the* Enkipaata *dance, part of* Eunoto, *the ceremony in which they graduate to elderhood. During the dance, the warriors may fall to their knees and wave their headdresses in unison.*

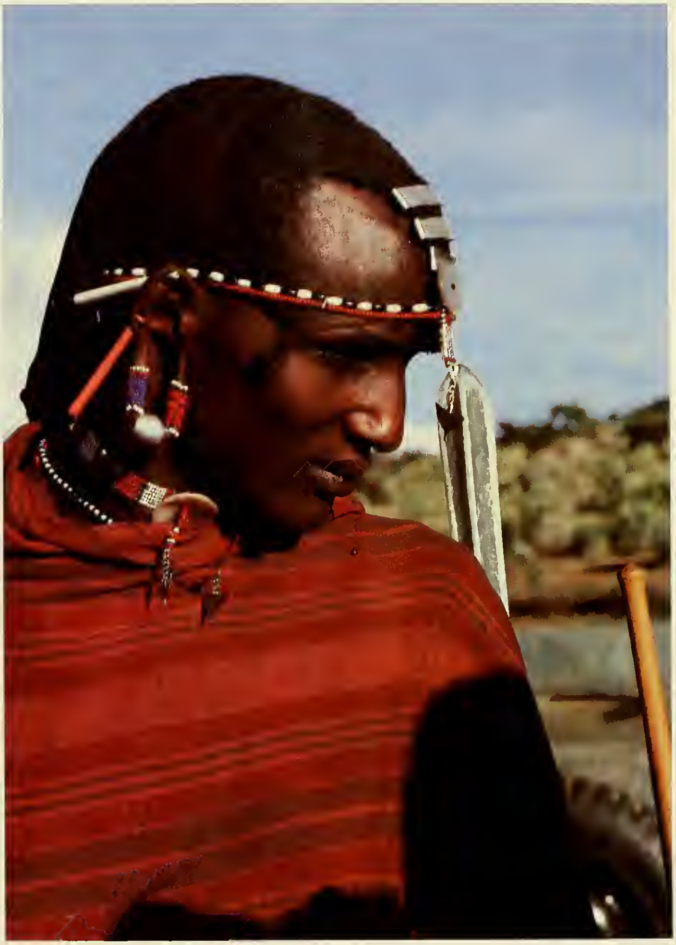
work requiring strength or courage people will ask, "Are there no warriors around today?" Warriors are needed both for simple tasks—capturing a cow to be slaughtered for a ceremony and decorating it with bells, wrestling with one to be branded—and for dangerous ones—protecting the herd from lions or subduing a crazy rhino charging through the kraal. Maasai warriors in their prime seldom fall short in the performance of their duties. When praised, they will modestly answer, "All we did is what Maasai warriors are supposed to do."

I remember from my own experience as a warrior how self-confidence takes over the whole being, along with pride and a feeling of ease, as if you yourself and all those around you were thinking, "Everything will be all right as long as the warriors are here." We were supposed to be brave, brilliant, great lovers, fearless, athletic, arrogant, wise, and above all, concerned with the well-being of our comrades and of the Maasai community as a whole. We realized that we were totally trusted by our community for protection, and we tried to live up to their expectations. If, for example, a lion would roar near our kraal at night, we would be so insulted at his boldness. All we would wish for was daybreak so that we might go in search of him, hunt him, and teach him a lesson: that we warriors, and not he, reign supreme. We used to say that until a lion could roast his meat, that is, stop eating raw meat, he would never be able to challenge us. And we used to boast that although a lion could run faster than we could, we could run farther.

Maasai warriors are so fearless that a German writer by the name of Karl Peters observed, at the turn of the century, "The only thing that would make an impression on these wild sons of the steppe was a bullet . . . and then only when employed in emphatic relation to their own bodies." Warriors are reputed to be afraid of nothing short of Almighty God; even foreigners do not scare them. Often they do not bother to distinguish persons dressed in foreign clothes from each other, be they white or black. They sum up foreigners with the word *ilmeek*, meaning "aliens," or *iloridaa enjekat*, meaning "those who confine their farts." This last term refers to the nature of European clothes, which

do not allow the wind to blow away any unwanted odors, as does the Maasai toga.

Besides this most important quality of bravery, Maasai warriors have many other virtues. One of these is the strong comradeship they feel for each other. Maasai warriors share practically everything, from food to women. According to tradition, a warrior must never eat alone. This was first made a law in order to ensure that every warrior, even one from the poorest family, would have enough to eat. And even today, warriors roam Maasailand always in groups, never alone, for this reason. There are even certain sections that forbid a warrior to drink milk from his own cattle, in an attempt to encourage sharing rather than selfish monopoly.



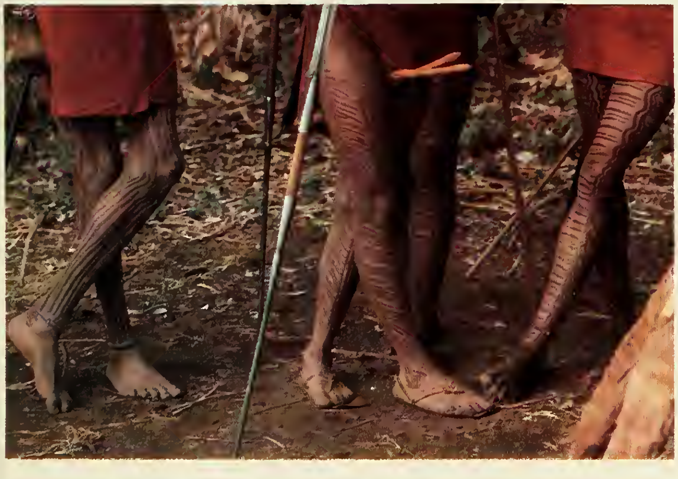
*Above: This warrior, his spear point-up by his side, has plaited his hair and decorated himself with metal ornaments, colorful beadwork, and disks made from crocodile eggshells. Girlfriends fashion beadwork ornaments for the warriors. Left: Maasai houses, arranged in a rough circle called an* engang, *are made of woven tree branches patched with leaves and grass and plastered with dung. Protection from the heat of the day is provided by large acacia trees; the species shown here is nicknamed "the shade tree."*

The physical appearance of the Maasai warrior expresses all the qualities that the Maasai, and even many foreigners, consider desirable. This is particularly true when the warriors are seen in full war gear on their way to a cattle raid or to retrieve stolen cattle. Like finely crafted bronze statues, the warriors appear in full regalia with headdresses of gleaming black ostrich feathers or lions' manes, elaborately patterned shields of buffalo hides, and spears glistening in the sun. They are both admirable and awe-inspiring. Today, restricted by the ban on hunting wild animals, the Maasai find it harder and harder to obtain buffalo hides for their shields and lions' manes for their headdresses.

Their physical beauty and the decoration of their bodies are important to Maasai warriors in times of peace as well. Anxious to attract girls, they spend hours decorating themselves with ocher and plaiting their hair. They first grind the ocher, then mix it with fat or water. After this mixture is applied to the legs and while it is still wet, decorative patterns are drawn with the fingertips or a stick. Warriors braid their hair into long plaits, often twisting in strands of wool to create greater length, and then dye it red with a mixture of ocher and fat. They adorn their earlobes, necks, arms, waists, and ankles with the beaded ornaments made by their female suitors.

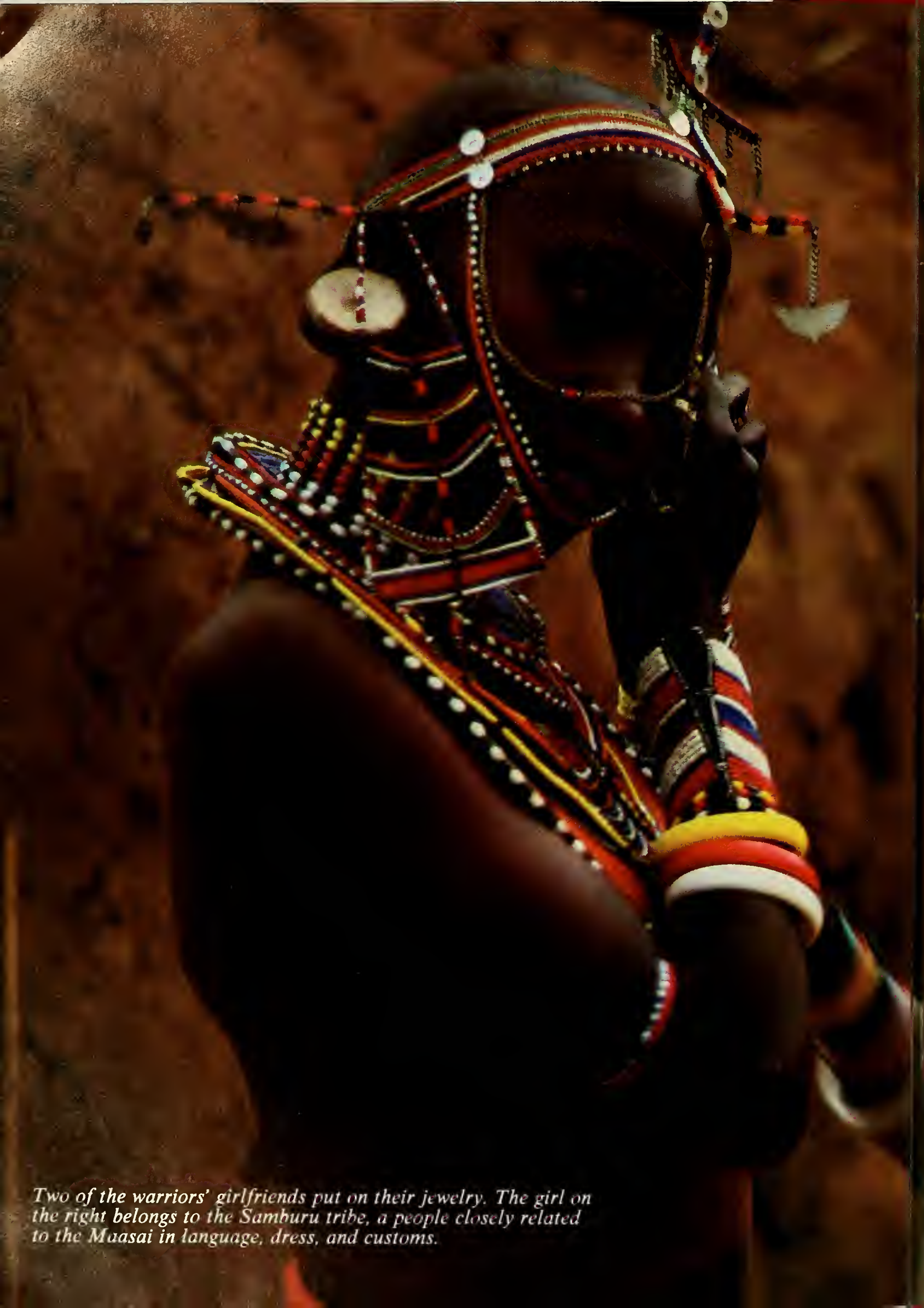
The ever present spear of a Maasai warrior is a most precious possession. A traveler in Maasailand often sees the lightning flash of a Maasai spearpoint gleaming in the distance before the silhouetted body of a warrior appears. The warriors develop a worshipful trust in their weapons, and certain braves will never flee from an attack as long as their spears are still in their hands, for fleeing would be like betraying their weapons. The warrior anoints his spear with animal fat and polishes it often to prevent rusting. All day long, the spear is held in the warrior's hand or thrust, point-up, into the ground by his side. It would be considered a serious insult to a Maasai warrior if anyone were to insert his spearpoint into the ground. At night it is stored inside by his girlfriends. Not used for fighting alone, the spears are sometimes decorated to symbolize peace. Pure black ostrich feathers are attached to the tip of the spear with

*Left: In jumping dances, Maasai men often compete for the highest leap, but the rhythmic jumping always appears effortless. The men, who participate in these dances throughout their lives, stand in a circle and sing with a strong, breathy beat while one or two of them jump in the center of the circle. They accentuate the peak of their leaps by trembling their shoulders. Below: During warriorhood, Maasai males periodically go off to a feasting camp, called* olpul, *to gain strength, share wisdom and lore, and prepare for lion hunts and cattle raids. When they return, they play among themselves and with their girlfriends, with whom they gather to sing and dance at the end of the day. Bottom: In addition to styling their hair, warriors decorate their legs, using their fingers or sticks to paint patterns in the wet ocher or chalk with which they cover their legs.*

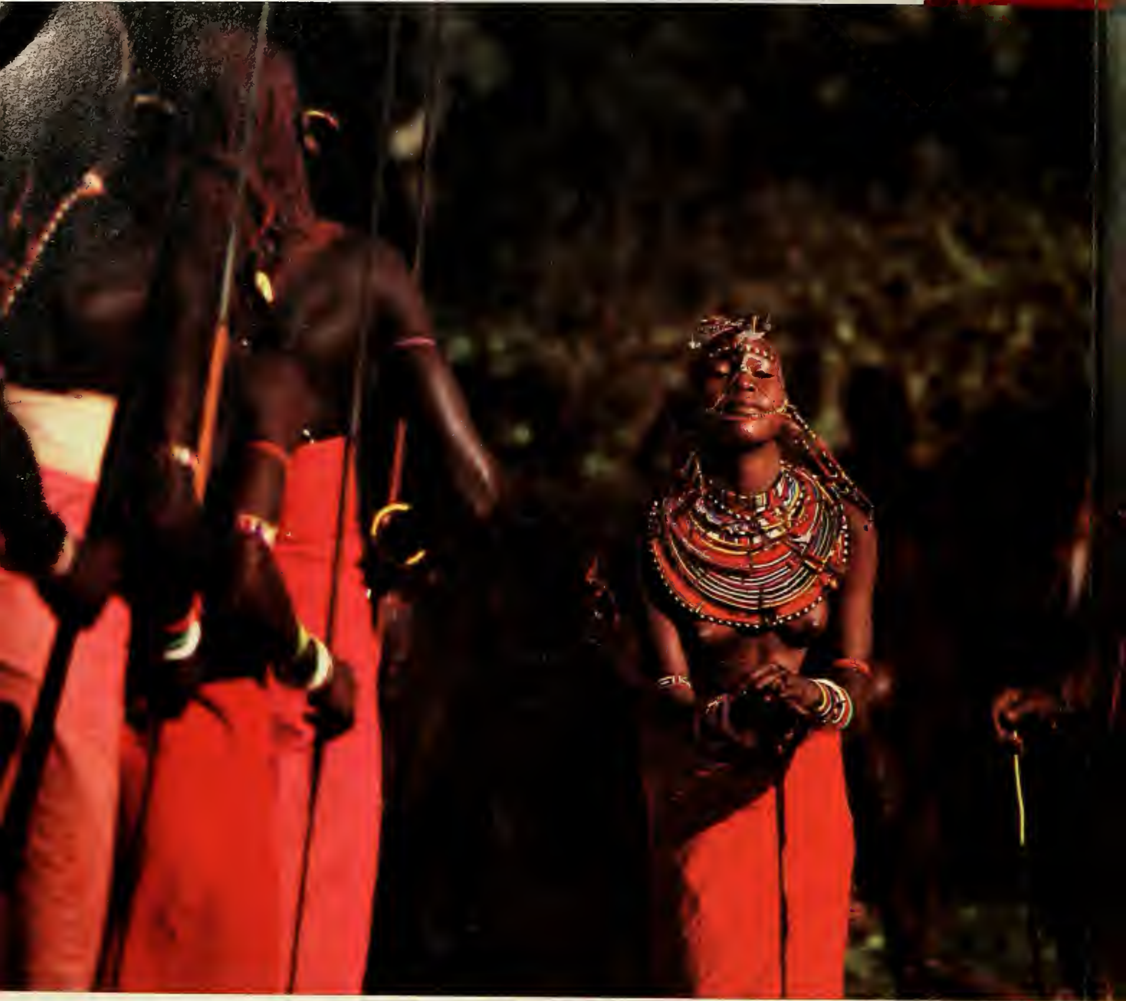


a string of beads, forming a round crown. A piece of black ebony may be inserted into the spear shaft to indicate a warrior's seniority, while a section of pale wood indicates his junior status.

The activities of Maasai warriors are many. Within their family communities, they are very helpful, performing such tasks as building thorn fences to protect the herds, clearing sand from wells, and watering cattle during the harsh dry season. Warriors tend the cattle only if they have no younger brothers to help them. When not working, the warriors group together to sing or play. A common game involves throwing wild sisal stalks or the round yellow fruits known as "Sodom apples" at each other and fending off the blows with their



*Two of the warriors' girlfriends put on their jewelry. The girl on the right belongs to the Samburu tribe, a people closely related to the Maasai in language, dress, and customs.*



*As young Maasai girls dance with the warriors, their beaded necklaces flip up and down, creating a dazzling show of color, above. After* Eunoto, *a man may marry. But the ceremony also marks the end of warrior comradeship. As they march to the ceremonial site, many warriors become crazed with emotion and are calmed by their mothers and other warriors, above right. Throughout* Eunoto, *warriors gather in small groups to decorate themselves, right.*

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shields. This game gives them much practice in using their shields effectively. Sometimes they chase their beautiful girlfriends, teasing them with branches, or get into mock fights with them.

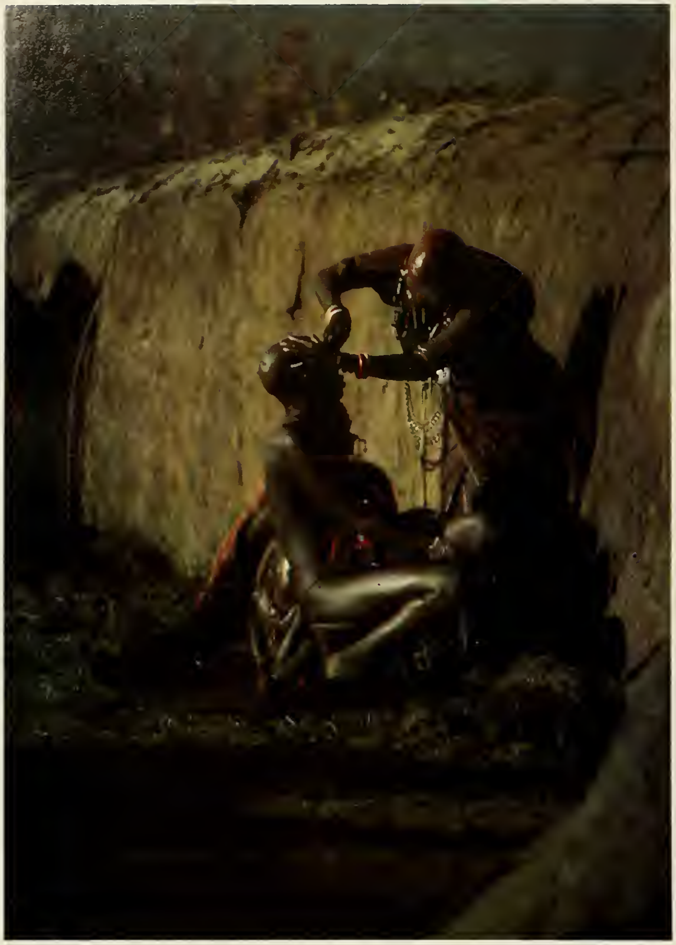
Another activity of the warrior is called *enkitoongiwong*. This involves a vigilant exploration of their surroundings to obtain news and defend against danger. On certain occasions when warriors are happy, such as during the rainy season, they hunt lions as a demonstration of bravery and courage. This formal lion hunt is called *alamaiyo*.

Although the government has forbidden them, cattle raids and lion hunts are still held, on a small scale, by Maasai warriors. Maasailand is so immense that it is hard for the government to patrol it properly. Before it was forbidden by the colonial governments in the early 1900s, cattle raiding was a popular and useful warrior's occupation. A cattle people who believe that all the cattle on earth belong to them, the Maasai would go on cattle raids to retrieve herds from other tribes, which they believe must have been taken from them long ago. First, scouts would be sent out to find large non-Maasai herds suitable for raiding. They would return with cattle dung as proof of their success, and the necessary number of warriors, sometimes as many as one thousand, would be mobilized. In recent days, cattle raiding is no longer a formal, colorful public display, but is instead pure theft. Those few diehard warriors who still raid must be very discreet, for if they were arrested by the government authorities they would be severely punished.

Because of their sacred love of cattle, however, the Maasai will always be enemies of any outsider, African or European, who keeps cattle. The warriors are still a Maasai standing army ready to defend their land and cattle from enemy attack. Tall, handsome, and fearless, they will fight to the end. It would be in proud pursuit of cattle that all Maasai warriors would wish to die if death must come.

The plains and rolling hills of their broad land must have witnessed, many a time, Maasai warriors in action. Their weapons are treacherous—the sharp sword with a double edge used to hit and slash; the short club with a round head used for beating or

*Warriors, with their girlfriends and mothers, participate in song and dance*



*As they prepare to embark on the new life of elderhood, warriors must part with their long hair. Mothers who have not indulged in sexual relations with warriors of their sons' generation have the honor of shaving their sons' hair, a highly emotional and sad part of* Eunoto, *above. With their shaved heads freshly ochered, right, warriors come together to sing and dance in a special enclosure made by forty-nine skin-covered houses. Within this enclosure is the* Osingira, *or ritual house.*

throwing at the enemy; the stick with sharp points at each end, which is hurled at the enemy; and, indeed, the spear with its invisible thrust, the warrior's best friend. One looking at Maasai dress can observe certain resemblances to the attire of the ancient Romans, who once occupied North Africa. The Maasai sword resembles the short Roman fighting sword; the warriors' hairdo follows the shape of the Roman helmet; and the toga and sandals are similar in style to those of the Romans.

Warriors have various traditional war formations for approaching the enemy, depending on whether he is positioned in open plain, forest, or bush country. If the enemy is in open country, for instance, they close in, carrying enormous buffalo shields,

and create a wall of warriors in an eagle-wing formation. The bravest warriors form a spearhead in the center to split and penetrate to the heart of the enemy line. Others will be positioned on the sidelines to give support to the spearhead. Behind the spearhead there is the rear guard, which comes to the rescue in case the front is overpowered. (The last major Maasai war was fought by the Tanzanian Maasai against the Bantu tribes around Lake Victoria during World War I. The Maasai were aware that the Germans and British rulers of East Africa were preoccupied with the war and were not in a position to stop intertribal warfare. They were most successful in their main purpose, which was to gain cattle to build up their decimated herds.)

While Maasai warriors are famous for being unbeatable during battle, they also know how to accept defeat. They will always say, "The war will be won by either side, ours or theirs," as the following song illustrates:

God, bird of prey,
Accompany me on the raid,
Because if I don't get killed,
I will kill, and you will always have
One of us to feed upon.

When the pressure from the generation below them becomes great enough, warriors are forced to graduate into elderhood to make room for the new generation. The most important ceremony involved in this transition is called *Eunoto*, literally, "planting." In one of the most sentimental moments of the ceremony, the mother of each warrior shaves off her son's long plaited hair, softening it with a mixture of milk and water.

Often the warriors will cry or go into an emotional frenzy, shaking all over and foaming at the mouth, desolate at the loss of the beautiful long hair that has been a proud possession during the highest period of their manhood. They hate the idea of their approaching elderhood, which marks the coming of old age and the end of warrior comradeship. "Now that you are an elder drop your weapons and use your head and wisdom instead." "Master the art of the tongue and wisdom of mind." "Family responsibility rests on your shoulders." Such words echo in the mind of the Maasai as he embarks on the new life of elderhood. □

# The World's Greatest Lakes

*Lake Baikal (shown here) and Lake Superior have similar wonders, beauties . . . and problems*

**by Wayland R. Swain**

It is difficult, if not impossible, to describe anything associated with Siberia without using superlatives. Even its name reflects its size. "Siberia" was derived from the word Сибир (Sibir'), which, in the language of the ancient Buryats who dwelled in the area, means "the sleeping giant."

Precise measurements of the sleeping giant's domain vary, depending on the inclusion or exclusion of certain eastern provinces, but conservative estimates suggest this vast landmass is in excess of four million square miles. In the heart of this immense landscape, two-thirds of the way from the Urals to the Pacific Ocean, lies the oldest and largest body of fresh water in the world, the earthquake-riven basin known as Baikal. Lake Baikal has a special place in the hearts of Russians. Called variously Sacred Baikal, the Sacred Sea, or the Glorious Sea, it is thought of with a reverence that outshines any such widespread feeling about the Great Lakes in this country. It was, in fact, our Great Lakes that brought me to Russia.

I traveled, with ten other Great Lakes scientists, aquatic toxicologists, and administrative personnel to the Soviet Union under the auspices of the U.S.–U.S.S.R. Joint Agreement on Environmental Protection. We went to attend a scientific symposium and to compare Baikal, this "elder of the tribe" among the world's freshwater bodies, with our own North American Great Lakes, particularly, the appar-

Paolo Koch, Photo Researchers

ent relationship with Lake Superior. There were differences, to be sure, but in many ways, they only emphasized the similarities.

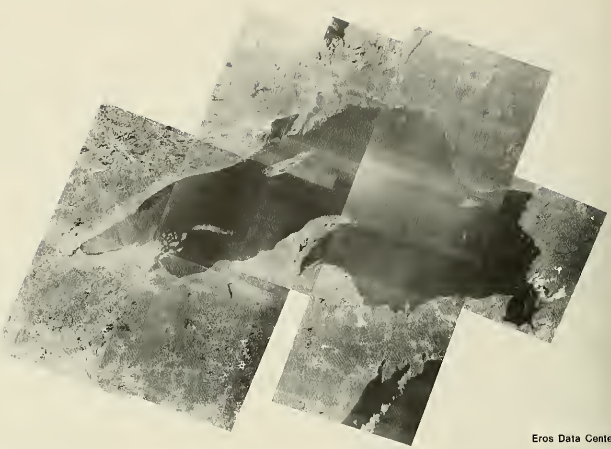
In the Superior-Quetico Wilderness bordering Lake Superior, spring wildflowers erupt through the thin soil layer in June. A month later, the process is repeated on the shores of Lake Baikal. Lilacs blossom, migratory waterfowl return, and gentle spring rains fall. As I knelt on the shoreline to take samples of the water, 20,000 miles vanished, and it was nearly impossible to separate Baikal from Superior by outward appearances alone. The shorelines of both lakes consist of pebble-strewn beaches flanked by craggy rock outcroppings and escarpments that rise to impressive heights and provide a springboard for numerous rivulets and miniature waterfalls, which cascade into the basin. Astonishing in clarity, bone-chilling in temperature, and of a hue and intensity of blue to beguile poets, the water in Baikal and Superior appear to have been derived from the same source.

These lakes are of such proportions that, like Siberia, they can only be spoken of in superlatives. Superior, the largest lake in the world by surface area (31,820 square miles) is fed by more than 200 tributary streams and is drained by but a single outflow, the Saint Mary's River. Baikal, the world's largest lake by volume (5,500 cubic miles) is fed by 336 tributaries, and also gives rise to a single outlet, the mighty Angara River.

Nearly 400 miles in surface length, Baikal has some 1,300 miles of shoreline. Superior, while nearly the same surface length, has 1,800 miles of shore. But, while the volume of Superior is taken to be 3,000 cubic miles, Baikal holds 5,500 cubic miles of water, almost enough to fill the basins of all five of the North American Great Lakes (slightly more than 6,150 cubic miles). Superior's deepest section is of the order of 1,330 feet, and Baikal's maximum depth is now given as 5,314 feet, more than three times that of Superior. Freshwater more than a mile deep is impressive, and even more so when one considers that an additional four miles of sediments have accumulated in the bottom of the Baikal trench as a result of its 20 to 30 million years of existence. Superior is but a youth by comparison, only about 10,000 years old.

The way the basins of the respective bodies of water were created accounts, in part, for both their differences and similarities. The rocky fault that holds the waters of Baikal resulted from a massive shifting of the earth's crust in that region. A monumental series of earthquakes is thought to have been responsible for creating the great rift that forms the present lake basin. Current theory suggests the lake may well be the forerunner of a new ocean that will divide the northern and southern portions of the Asian subcontinent into two distinct landmasses.

It could be said that Baikal is still in the process of creation, even after millions of years. As recently as 1861, a massive earthquake and a series of aftershocks of catastrophic proportions caused a seventy-square-mile portion of the eastern shoreline to fracture and sink, drowning some 1,300 inhabitants of the region, and creating a new arm of the lake called Proval Bay.



Eros Data Center

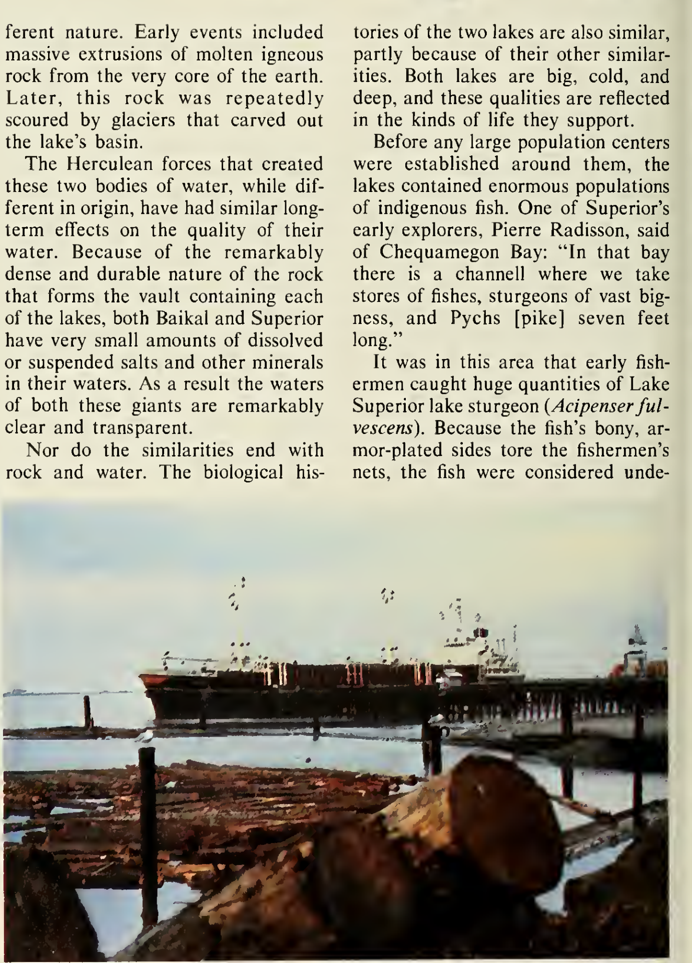
The sequence of events that created Lake Superior was of an entirely different nature. Early events included massive extrusions of molten igneous rock from the very core of the earth. Later, this rock was repeatedly scoured by glaciers that carved out the lake's basin.

The Herculean forces that created these two bodies of water, while different in origin, have had similar long-term effects on the quality of their water. Because of the remarkably dense and durable nature of the rock that forms the vault containing each of the lakes, both Baikal and Superior have very small amounts of dissolved or suspended salts and other minerals in their waters. As a result the waters of both these giants are remarkably clear and transparent.

Nor do the similarities end with rock and water. The biological histories of the two lakes are also similar, partly because of their other similarities. Both lakes are big, cold, and deep, and these qualities are reflected in the kinds of life they support.

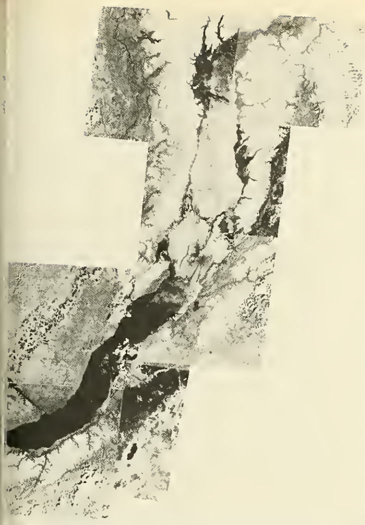
Before any large population centers were established around them, the lakes contained enormous populations of indigenous fish. One of Superior's early explorers, Pierre Radisson, said of Chequamegon Bay: "In that bay there is a channell where we take stores of fishes, sturgeons of vast bigness, and Pychs [pike] seven feet long."

It was in this area that early fishermen caught huge quantities of Lake Superior lake sturgeon (*Acipenser fulvescens*). Because the fish's bony, armor-plated sides tore the fishermen's nets, the fish were considered unde-



*Logs from the shores of Lake Superior*

Jim Brendenburg



*USGS Landsat composite photographs of Lake Superior, left, and Lake Baikal, right, shown to scale*

sirable and were stacked, like cordwood, in great piles on the beach and burned. Today, in Superior, this species is virtually extinct.

In Baikal, overfishing for what was once the most valuable food fish of the lake, the Baikal sturgeon (*A. baeri baicalensis*), reduced the population so drastically that for a time, recovery was not thought possible. For some years, fishing for the Baikal sturgeon has been strictly forbidden. Consequently, the sturgeon population is now steadily growing and one day may again reach its original proportions. Two specific characteristics of the adult fish were responsible for its decline in Baikal. The fish, which can grow to a length of seven to ten feet and weigh more than 500 pounds, not only has delicious flesh but, in season, also yields quantities of greatly valued black caviar.

Both lakes have fishy oddities of less dramatic proportions. Baikal is noted for the Baikal omul, *Coregonus autumnalis migratorius*. This salmonid fish, a member of the whitefish and lake herring family, represents the single most important species of modern commercial fishing on Baikal, accounting for more than two-thirds of the annual commercial catch. The omul is about twelve inches in length as an adult (between six and seven years) and has a delicate flavor, somewhere between that of lake trout and whitefish. It is said that no true Siberian dinner is complete without at least one dish of omul.

This fish is also known for giving a piercing cry when it is hauled from the icy waters. Thus, when residents of the area speak of someone who is given to extensive whining or complaining, they say, "He cries like an omul."

Lake Superior has the siscowet trout, or fat lake trout (known simply as "fats" to local commercial fishermen). This deep-water species is adapted for living in the intense cold and pressure of the depths of Lake Superior. As an adult, this fish weighs fifteen to twenty pounds; 30 to 50 percent of its body weight is natural oil. When hauled from 600 to 900 feet of water and laid on the deck of a ship, the fish succumbs to its own weight, and under the pressure of gravity its tissues compress, forcing out pools of oil.

Baikal has its own oily fish, the golomyanka. Two subgroups of this fish exist in Baikal and nowhere else. They differ primarily in length, one being approximately six inches long, the other slightly more than eight inches. The golomyanka bears live young. Each female produces about 2,000 progeny each autumn, and a large percentage of females do not survive the process. When they die, most sink to the bottom, but females of the larger golomyanka species frequently float to the surface and are washed ashore in great masses. Its large quantity of body oil, 35 percent or more by weight, makes the fish both transparent and buoyant. When cast ashore by wind and wave, these fragile creatures literally melt away in the heat of the sun, leaving only cartilaginous skeletal structures behind them. Like Superior's siscowet trout, Baikal's golomyanka are so adapted to cold water that temperatures above 45 degrees Farenheit are fatal to them. This fish remains in the dark, cold regions at depths of 700 to 1,600 feet during daylight hours, and migrates to the surface at night where it becomes the favorite food of another unique and endemic animal in the Baikal ecosystem, the nerpa, or freshwater Baikal seals, whose nearest relatives are to be found some 2,000 miles to the north in the Arctic Ocean. Known scientifically as *Phoca sibirica,* the nerpa has an estimated population in excess of 25,000 individuals. Some controlled hunting is still permitted, and the population continues to grow slowly. Because they are furtive creatures, the nerpas' exact population densities could not be determined until the advent of helicopter surveys. However, the lake's extreme transparency favors the census takers, since there is apparently no depth to which seals usually dive that cannot be observed from an aerial platform such as a helicopter.

The crustacean populations of Superior and Baikal may also be singular in the world. Superior supports a zooplankton community that is consistent with a deep, cold lake of high water

*Lake freighter on the southwest shore of Lake Baikal*

Paolo Koch, Photo Researchers

quality. Populations include such outstanding representatives as an opossum shrimp, *Mysis relicta.* Baikal, on the other hand, supports a unique, shrimplike amphipod found nowhere else in the world. Until recently, it was thought that Baikal also contained a singular multisegmented worm, a polychaete, that was unique. Not long ago, however, this creature, known as *Manayunkia baicalensis,* has been found to have a close relative, *M. eriensis*, in the Superior area and elsewhere in the Great Lakes.

Baikal is not only much older than Superior, but also has a greater number of species endemic to it alone. More than two-thirds of the plant species in the Baikal ecosystem fall into this category. One regrettable similarity between the lakes has more to do with human activity than with the lakes themselves. Since the late 1950s, industrial development has threatened to alter the ecology of both lakes. At about that time, a new technique for separating low-grade iron ore from its surrounding rock matrix was put into practice in a plant on the shores of Lake Superior. This plant released 69,000 tons per day of crushed rock flour into the Superior ecosystem. In addition to its effects on lake life, this material was later found to contain asbestos fibers, which had potentially serious health consequences for the region's human residents.

During the same time period, industrialization came to the Baikal basin. In 1957, an industrial division of the Soviet government suggested that the vast timber resources of the taiga and the pure water of the Baikal basin should be put to productive use. Planning announced the following year called for the development of two new major industrial developments—a cellulose factory on the Selenga River and construction of a facility to manufacture ultrapure cellulose cord for use in the production of airplane tires. This new plant was to be located at Baikalsk on Baikal's southern shore.

Meanwhile, on Lake Superior, the pulp and paper industries of both the United States and Canada were manufacturing large quantities of paper and pulpwood products from the vast stands of timber adjacent to the Lake Superior basin. Similarly, industrial development began along the Selenga River, some seventy-five miles upstream from the Baikal basin. A number of factories came into existence, contributing a substantial amount of waste material to Baikal. Baikal and Superior soon began to show the effects of this human activity.

On Baikal, as on Superior, commercial fishing began to be threatened by chemicals that were being liberated into the aquatic environment, particularly toxic phenols and their associated byproducts, which have major effects on taste and odors associated with the flesh of fish. On Superior, commercial fishermen began to cease taking whitefish from areas where exposure to phenolic wastes might taint their catches.

The phenolic residues from the Baikalsk cellulose plant on Baikal's southern shore also affected the catch of the omul. As soon as this was recognized, the Soviet government undertook a series of tough legislative measures that served to minimize the extent of the problem. Even this may not have been enough, however. The effluent from the Baikalsk plant consistently meets or exceeds the standards for water quality in the Soviet Union, but these standards are well below the ultrapure quality of the waters of Lake Baikal. Thus, it is currently reported that the cellulose plant will either have developed a closed-cycle system by 1985 or the plant will no longer be permitted to operate.

Legislative and judicial steps have also been undertaken to eliminate waste effluents entering Lake Superior from mining facilities. As a result of an extended contest in the courts, the mining company has now begun to dispose of its waste products at a land site. In addition, massive efforts through the International Joint Com-

*Cleaning up around Lake Superior*

Jim Brandenburg

*Fishing boats, Lake Superior*

Tom Stack; Tom Stack and Associates

mission, a treaty body established between the governments of the United States and Canada for the purpose of promoting water quality in the Great Lakes, have resulted in the identification of major problem areas related to water quality. Concerned scientists anticipate that as a result of the efforts of this body, effluent standards will be such that the problems of phenolic and other toxic discharges may soon be contained.

Regrettably, however, containment alone may not be sufficient. New and perhaps even more insidious threats, consisting of the introduction of man-made chemicals of recent origin, have been identified for both the Superior and Baikal ecosystems. First evidence of the potential impact of these compounds came from a study that was done on Lake Superior's Isle Royale. A rock-strewn conglomerate of island masses and associated irregular shore reefs, Isle Royale is seventeen miles from the nearest shoreward margin of Lake Superior at Thunder Cape, Ontario, and more than thirty-two miles from Thunder Bay, Ontario, the nearest major population center. The entire island structure, including its associated reefs and islets, was established as Isle Royale National Park in April 1940. Since then efforts have been made to retain the island's native wilderness character. Siskiwit Lake, a small, deep lake on Isle Royale, was selected for study of background levels of man-made toxic organic chemicals because it was remote from inhabited areas, and free from direct industrial and/or cultural influences attributable to humans. Furthermore, the areas surrounding Siskiwit Lake had never been logged nor had mining operations or the use of heavy equipment ever been permitted in the near vicinity. No internal combustion engines have ever been allowed, and even the air space above and adjacent to the park is restricted, thus avoiding localized contamination from aircraft. In short, a more isolated and remote spot is difficult to imagine.

*Picnickers, Lake Baikal*

Jerry Cooke

*Fishing boats, Lake Baikal*

Paolo Koch, Photo Researchers

Samples of fish from Siskiwit Lake were analyzed for man-made toxic contaminants. The results indicated a marked increase in toxic organic substances in Siskiwit Lake as compared with levels in fish taken from Lake Superior's surrounding water mass. This surprising evidence led to the conclusion that these substances had to have been airborne in order to reach this remote site. To test this hypothesis, samples of fresh snowfall from Siskiwit Lake were compared with similar fresh snowfalls in the metropolitan areas of Chicago, Illinois, and Duluth, Minnesota/Superior, Wisconsin. All samples were tested for polychlorinated biphenyl compounds (PCBs), ubiquitous, man-made toxic substances, and the mean value for PCBs in the snow from Siskiwit Lake turned out to be five times higher than similar values for the metropolitan areas sampled. This study suggested that long-range atmospheric transport of toxic organic substances was of major importance to the Lake Superior ecosystem.

With the knowledge that Lake Baikal is thousands of miles from any major source of toxic organic compounds of anthropogenic origin, researchers analyzed samples of deep sediments from the southern portion of the Lake Baikal basin and confirmed the presence of phthalic acid esters. Phthalate esters are used as plasticizing, or softening, compounds to make brittle plastics more pliable. The presence of such pollutants in such a remote ecosystem as Baikal again suggests the potential for long-range transport of products of our present technological age.

Because of the diffuse nature of these inputs, future control strategies and measures for the protection of both the Baikal and Superior ecosystems may be far more difficult than those required for previous actions. But, that it will be worth the effort to protect these two aquatic monarchs is without question. ☐

Material adapted from *The Social Life of Small Urban Spaces*, published by The Conservation Foundation ©1980 by William H. Whyte.

# Street Life

*What are the basic elements for successful open spaces in cities?*

**Text and photographs by William H. Whyte**

*With broad steps that provide good sitting space, sunshine, and an excellent view of the busy pedestrian traffic, the New York Public Library attracts a lively, social crowd.*

Ten years ago I formed a small group of observers and began looking at city streets and spaces in New York and how people used them. I did it because I thought it would be interesting, but as with all such enterprises, I had a proper research design and many fine hypotheses. Most were about overcrowding, which was then very much on peoples' minds. Experiments with mice were demonstrating that very high population densities induced neurotic behavior, and by inference, so did cities. What about people? How did they respond? How many were too many? In what circumstances? With the help of some foundation grants we set forth on our research—and a succession of broken hypotheses.

We started by looking at playgrounds and such informal recreation areas as city blocks. What soon struck us was the lack of crowding in many of these areas. A few were jammed, but more were nearer empty than full, often in neighborhoods that ranked very high in density of people. Sheer space, obviously, did not of itself attract children. But many streets did. One of the best play areas we came across was a block on 101st Street in East Harlem. It had its problems, but it worked. The street itself was the play area. Adjoining stoops and fire escapes provided prime viewing across the street and were highly functional for mothers and older people. There were other factors at work, too, and had we been more prescient, we could have saved ourselves a lot of time spent later looking at plazas. Although we did not know it then, this block had all the basic elements of a successful urban space.

As our studies took us nearer the center of the city, the imbalance in space use was even more apparent. Most of the crowding could be traced to a series of choke points—subway stations, in particular. Elsewhere, however, there was a surprising amount of underused space. Office building plazas were prime examples. Since 1961, New York City has been giving incentive bonuses to builders who provide public plazas; for each square foot of plaza, builders can add ten square feet of commercial floor space over and above the amount normally permitted by zoning. So they did—without exception.

We found that some plazas did attract people. The plaza of the Seagram Building was one. On a good day, there would be 150 people sitting, sunbathing, picnicking, and "shmoozing" —idly gossiping, talking "nothing talk." But on most plazas, there weren't many people. In the middle of the lunch hour on a beautiful, sunny day, the number of people sitting on plazas averaged four per 1,000 square feet of space, an extraordinarily low figure for so dense a center. The city

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was being had. For the millions of dollars of extra space it was handing out to builders, it had every right to demand much better plazas in return.

I put the matter to the people at the City Planning Commission. They agreed that tougher zoning was in order. If we could find out why the good plazas worked and the bad ones didn't and come up with hard guidelines, we would have the basis of a new code.

We set to work. We began studying a cross section of plazas, small parks, and street corners, and observing how people used such spaces. We mounted time-lapse cameras and recorded daily patterns. We talked to people too, but mostly, we watched them to see what they did. What attracts people, it became apparent, is other people. Many spaces are being designed as though the opposite were true, and that what people like best are the places other people stay away from. People often talk along such lines. They speak of getting away from it all, and use terms like "escape," "oasis," "retreat." What people do, however, reveals a different priority.

This was brought home to us in a study of street conversations. We wondered how far away people move from the main pedestrian flow when they stop to have a conversation. We were especially interested in finding out how much of the normally unused buffer space next to buildings was used. So we set up time-lapse cameras overlooking several key street corners and plotted the location of all conversations lasting a minute or longer. But the people didn't move out of the flow. They stayed in it or moved into it, and the great bulk of the conversations were held smack in the center of the flow—the "100 percent location," to use real-estate terminology. The same gravitation characterized "traveling conversations," those in which two men move about, alternating the roles of straight man and principal talker. There is a lot of apparent motion, but if you plot the orbits, you will find they usually revolve around the 100 percent spot. To a large degree, congestion is self-congestion. Just why, we have never been able to determine. That conversations should originate within the main flow is understandable. Where there are the most people, the likelihood of a meeting or a leave-taking is highest. What is less explainable is people's inclination to remain in the main flow, blocking traffic, being jostled by it. This does not seem to be a matter of inertia, but of choice—instinctive, perhaps, but by no means illogical. In the center of the crowd you have the maximum choice—to break off, to continue—much as you have in the center of a cocktail party, itself a moving conversation growing ever denser.

*Although quite loud, the sound of the waterfall in New York's Paley Park is a pleasant noise that masks conversation, thereby adding a feeling of privacy to a small, crowded area.*

People like to sit in the mainstream. At the Seagram plaza, the main pedestrian paths are on diagonals from the building entrance to the corners of the steps. These are natural junction and transfer points, and there is usually a lot of activity at them. They are also a favored place for sitting and picnicking. Sometimes there will be so many people that pedestrians have to step carefully to negotiate the steps. The pedestrians rarely complain. While some will detour around the blockage, most will thread their way through it.

Standing patterns are similar. When people stop to talk on a plaza, they usually do so in the middle of the traffic stream. They also show an inclination to station themselves near objects, such as a flagpole or a pillar. They like well-defined places such as steps or the border of a pool. What they rarely choose is the middle of a large space. The preference for pillars might be ascribed to some primeval instinct: you have a full view of all comers but your rear is covered. But this doesn't explain the inclination men have for lining up at the curb. Typically, they face inward, toward the sidewalk, with their backs exposed to the dangers of the street.

Foot movements are consistent, too. They seem to be a sort of silent language. Often, in a group no one will be saying anything. Men stand bound in amiable silence, surveying the passing scene, then, slowly, rhythmically, one of the men rocks up and down: first on the ball of the foot, then back on the heel. He stops. Another man then starts the same movement. Sometimes there are reciprocal gestures. One man makes a half-turn to the right; after a rhythmic interval, another responds with a half-turn to the left. Some kind of communication seems to be taking place here, but I have never broken the code.

Whatever they may mean, people's movements are one of the great spectacles of a plaza. You do not see this in architectural photographs, which typically are empty of life and taken from a perspective, often a misleading one, that few people share. At eye level you see movement and color—people walking quickly, walking slowly, skipping up steps, weaving in and out on crossing patterns, accelerating and retarding to match the moves of others. There is a beauty that is beguiling to watch, and the players themselves seem aware of it. With its brown-gray monochrome, the Seagram plaza is the best setting for them—especially in the rain, when an umbrella or two spots color in the right places, like Corot's red dots.

From city to city, behavior patterns are much the same. The strongest similarities are found among the world's largest cities. People in them tend to behave more like their counterparts in other world cities than their fellow countrymen in smaller cities. For one thing, big-city people walk faster and tend to self-congest more. In a brief comparison study we made in Tokyo, we found that the proclivity to talk in the middle of doorways and busy corners was just as strong as in New York. Similarly, in Milan's Galleria the conversational groupings were remarkably like the patterns on Seventh Avenue.

Next we turned to the physical characteristics of plazas and how they might explain why lots of people sat on some plazas, but only a few on others. I had hypothesized that sun patterns were the critical factor. For a while, our time-lapse studies bore this out: where the sun was, the people were; where it wasn't, they weren't. Then the correlation vanished. As June followed May and the weather got warmer, people sat almost anywhere, sun or shade. Sun was important to have, certainly; but it did not explain the differences in popularity of plazas.

Nor did the shape of plazas. Some urban designers were sure that the proportions of the spaces were critical, and they were especially interested in ruling out long, narrow spaces. But our findings afforded no documentation. Some long, narrow spaces looked

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*"Undesirables" such as derelicts and winos tend to appear in empty areas that are unattractive to other people because of lack of sitting space or prohibitions against loitering or eating.*

terrible and were empty most of the time, but so were some square spaces. Two of the most successful places in the city were long, narrow spaces.

Could the *amount* of space be the key factor? A number of conservationists thought so; in their view, people seek open spaces as a relief from the overcrowding they normally experience. If we were to rank plazas by the amount of open space provided, there would likely be a rough correlation between the size of the plazas and the number of people using them. There was not; if anything, there was a reverse correlation.

We turned to the amount of sittable space. Here we got closer. We went on to check many other factors: enclosures, pedestrian flows, nearness to transit, and such. But as we piled up all the data, overlay by overlay, one major finding emerged: People tend to sit most where there are places to sit.

This may not be an intellectual bombshell, but at the time it was not at all obvious to a number of architects and planners. They believed aesthetics of design were what drew people to come and sit. Some still do.

The key variable, however, is sitting space, and the places that have it tend to be good in other respects as well. Sittable space means choice. It is all the better, of course, if the space is physically comfortable: benches with backrests, for example, or well-contoured chairs. But more important is that it be socially comfortable. That is why ledges are so functional. They give people lots of room to sort themselves out; all the more so if the ledges are two backsides deep.

Steps are also great for sitting. They give a fine view of the theater of the street and provide an almost infinite combination of groupings. Corners of steps are especially popular. The right angles are very good for groups and at lunchtime are quickly preempted for picnics. This should create conflict. Since people generally take the shortest cut, the corners of steps are also precisely where the pedestrian traffic is usually heaviest. Still it all seems to work out. For all the coming and going, the sitters seem quite comfortable. The walkers don't seem to mind either and will carefully negotiate their way through the sitters rather than detour to the open areas. Sometimes the whole length of the steps is blocked by sitters. This is a good sign, the hallmark of an unusually successful place.

Although benches can work well, too often they do not. They are usually too small; there are too few of them; and they are spotted in isolation, one from the other, like design objects. Benches should be generously proportioned and flexibly arranged. Fixed individual seats are not good. The trouble with them is that they are set pieces. Social distance is a subtle measure, ever changing, and since the distances of fixed seats do not change, they are rarely right for anybody.

Best of all is the movable chair. It is a splendid invention and for more reasons than comfort. Its movability is the secret. A chair provides the maximum amount of choice—in the sun, out of it, up front, to the back—and the possibility of choice is more important than the exercise of it. Watch people as they approach a chair. They will probably move it; there seems to be a deep impulse in us to do so. The move may be only a matter of a few inches and in many cases is followed by a series of countermoves, with the chair ending up where it was in the first place. But the moves have point; they are

an assertion of one's free will and satisfying to make.

Moves can also be a nice social ritual. When taking a chair next to some stranger, a person's moves say something to them. The message may be, Sorry about the closeness, but I'm going to respect your privacy as you will mine. A slight reciprocal move by one of the others may follow. Watching these exercises in civility is one of the pleasures of a good place.

Like a place to sit, the other major elements of a good urban space are basic, and while it might seem a contradiction in terms, they are *natural* elements. Sun, light, trees, water—nowhere is nature more important than in cities, where it is so marginal.

Sun is the prime example. True, a space can work without it. Paley Park in midtown Manhattan lost much of its sun to a building across the way; still it remains very popular. But something of great value has been lost. Watch how people make the most of what sun there is and you realize how primeval is our reaction to it.

We are losing sun to new construction at an alarming rate. The problem is not only the bulk of the buildings but also a design approach that virtually ignores the sun. Few buildings acknowledge their neighbors, nor are they required to. Incentive zoning has many bonuses for making buildings bigger, none for having them provide more sun. They could. The same buildings that block sun can also reflect it. On streets with buildings of limestone or other light-colored materials, the light bounced from them may make the shady side of the street measurably brighter. Such effects are inadvertent. Architects do sun studies for new buildings, more for defensive than other reasons, and tend not to fret over the consequences of shadows on other buildings. Neither do they consider the sun's positive benefits. With certain small changes, such as canting reflective panels on part of

*A band of street musicians attracts a crowd and provides a linkage between people, encouraging strangers to talk to each other when under ordinary circumstances they would not.*

*A movable chair provides the most choice in establishing social distance. The impulse to move the chair—even if only a few inches and with the chair ending up in its original position—is irresistible.*

a tower, the architect could bounce some much needed light into dark places—Paley Park, for example.

Water is an element that designers are using rather well. Some plazas and parks now provide waterfalls, waterwalls, sluiceways, water tunnels, meandering brooks, tranquil pools, or fountains. The sound of water may be its best feature; a waterwall is loud—about 75 decibels—but it is a "white" sound that masks street noises and other people's conversations.

Another good thing about water is the look and feel of it. I have always thought the water at the Seagram plaza is unusually liquid, and I think it's because you know you can splash your hands or stick your toes in it if you are of a mind to. Not so in some places. A guard will come up. Forbidden. Pools of water are set before people and then posted with signs telling them not to touch the water. In Chicago's Grant Park, the grand old Buckingham Fountain has been put off limits with an electrified fence around it.

Safety is the reason usually given for such measures, but there are better ways than electrocution to handle this problem. At the Auditorium Forecourt Fountain in Portland, Oregon, people have been clambering up and down its sluiceways and falls for some seven years. While it looks dangerous—designer Lawrence Halprin designed it to look that way—there have been no serious mishaps since the day it opened. This splendid fountain is an affirmation of trust in people and it says much about the good city of Portland.

Trees are so obvious an amenity, the wonder is we haven't planted far more of them. In addition to their many other virtues, trees make the best of a sitting space. They provide a satisfying enclosure: sitting under one you can see all of the passing scene, while feeling somewhat protected, cuddled—much as you do under the awning of a sidewalk cafe. Builders should be required to plant many more trees and, where possible, to plant them in groves. The overlapping foliage makes a fine canopy. Arbors can do the same.

Another basic is food. People will eat an astonishing amount of it outdoors, and if you want to seed a place with activity, food facilities will do it. Even a pushcart can be a strong draw. In New York you will see a pushcart vendor and a knot of people around him at almost every plaza or set of steps with a lively social life. Sometimes the police arrive with trucks and haul the carts away, a piece of street theater invariably greeted with boos from the bystanders. Some cities are much more puritanical; they forbid not only the purveying but also the eating of food outdoors.

They are robbing themselves of a dynamic. Food has a strong shill effect. Out of proportion to their numbers, people who eat ice cream cones, hot dogs, and lunch out of brown bags attract other people. There has been a notable increase in the use of plazas where tables, chairs, and snack bars have been set up. From the street it sometimes looks as if a big party is going on and the sight induces passersby to venture in.

Now we come to the key space for a plaza. It is not the plaza; it is the street. A good plaza starts at the street corner. A busy corner has a brisk social life of its own, and there will be considerable two-way traffic between plaza and corner. Another key feature of a street is retailing—stores, windows with displays and signs to attract your attention, doorways and people going in and out of them. Big new office buildings have been eliminating stores, replacing them with a frontage of plate glass through which you can behold bank officers sitting at desks. One such stretch is dull enough; block after block of them creates overpowering tedium.

The area where the street and the plaza, or open space, meet is a key to success or failure. Ideally, the transition should be such that it is hard to tell where one ends and the other begins. New York's Paley Park is the best of examples. The sidewalk in front is an integral part of the park. Arborlike foliage extends over the sidewalk. There are urns of flowers at the curb and curved sitting ledges on either side of the steps. In this foyer you can usually find somebody waiting for someone else—it is a convenient rendezvous point—people sitting on the ledges, and in the middle of the entrance, several people in conversation. Even passers-by who don't go into Paley benefit. About half will turn and look in. Of these, about half will smile. I haven't calculated a smile index, but this vicarious enjoyment is extremely important—the sight of the park, the knowledge that it is there, becomes part of the image we have of a much wider area. If one had to make a cost-benefit study, I think it would show that secondary use provides as much, if not more, benefit than the primary use.

If such places are so felicitous, why are there not more of them? The reason is the "undesirables." They are not, themselves, much of a problem. The problem is the measures taken to combat them. Many businessmen have an almost obsessive fear that if a place is attractive, it might attract undesirable people. So the area is made unattractive. There is to be no loitering, no eating, no sitting. Benches are made too short to sleep on, and spikes are put in ledges; most important, many needed spaces are not provided at all, or the plans for them scuttled.

Ironically, places designed with distrust get what they were ostensibly avoiding and it is in such places that you will most likely find a wino. You will find winos elsewhere, as well, but they prefer the empty places. The best way to handle the problem of undesirables is to create an area attractive to everyone else. The record is overwhelmingly positive on this score. With few exceptions, plazas and small parks in most central business districts are probably as safe a place as you can find during the times that people use them.

There is one more factor to consider. I call it triangulation. By this I mean that process by which some external stimulus provides a linkage between people and prompts strangers to talk to each other. There are, say, two men standing at a street corner. A third man appears, hoists a sign, and begins a loud harangue on the single tax. This links the first two men. Casually, they exchange comments on the scene before them, in a tone of voice usually reserved for close friends.

Musicians and entertainers also draw people together. Rockefeller Plaza and the First National Bank of Chicago regularly schedule touring school bands, rock groups, and the like. The real show, however, is usually the audience. Many people will be looking as much at each other as at what is on the stage.

Street performances are great crowd gatherers, and they have the virtue of unexpectedness. When people form a crowd around an entertainer—it happens very quickly, in 40 or 50 seconds–they look much like children who have come upon a treat; some will be smiling in simple delight. These moments are true recreation although rarely thought of as such, certainly not by the shopkeepers who try so hard to outlaw them. But people like them, and they are right.

I am not, heaven forfend, arguing for places of maximum gregariousness or social directors for plazas. Anomie would be preferable. What I'm suggesting, simply, is that we make places friendlier.

I am, in sum, advocating busy places. Too busy? Too crowded? I think not. People have a nice sense of the number that is right for a place, and it is they who determine how many is too many. Furthermore, they do not seek to get away from it all. They go to the lively places where there are many people. And they go there by choice, not to escape the city, but to partake of it. ☐

*Food facilities act as magnets to draw crowds. The sight of other people eating ice cream, hot dogs, or ethnic foods gives the street a party atmosphere that induces passers-by to join in.*

# Quakes along the Mississippi

*In the central part of this river valley, an ancient split in the earth's crust is the site of continuing seismic activity*

**by Robert M. Hamilton**

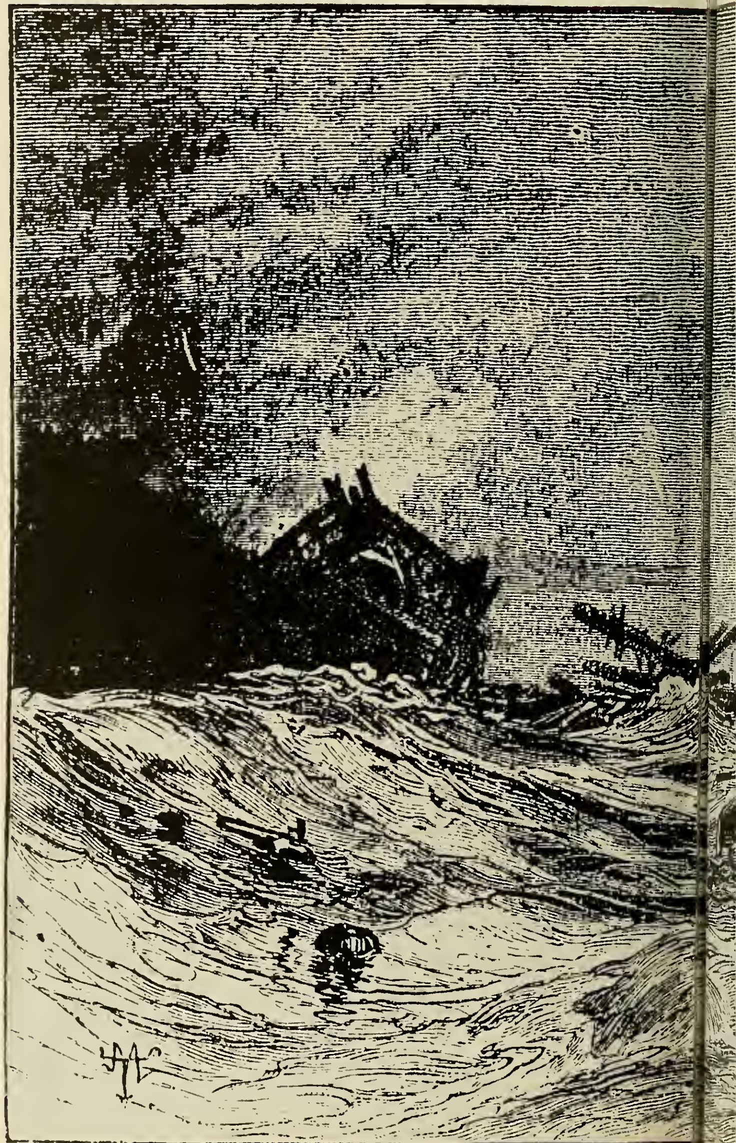
In the winter of 1811–12, the central Mississippi River valley was ravaged by a series of strong earthquakes. Spectacular disruption of the land took place over a vast area between the confluence of the Ohio and Mississippi rivers on the north and Memphis, Tennessee, on the south. Forests were flattened, chasms opened so wide that people felled trees to get across them, and land sank and was flooded to depths of several feet. Steep banks collapsed along the Mississippi and rapids formed in the river, which was even seen to reverse its direction of flow for awhile.

The first shock struck without warning at 2:00 A.M. on December 16, 1811, and was followed by hundreds of strong tremors. Similar strong quakes on January 23 and February 7 in 1812 were also followed by many aftershocks.

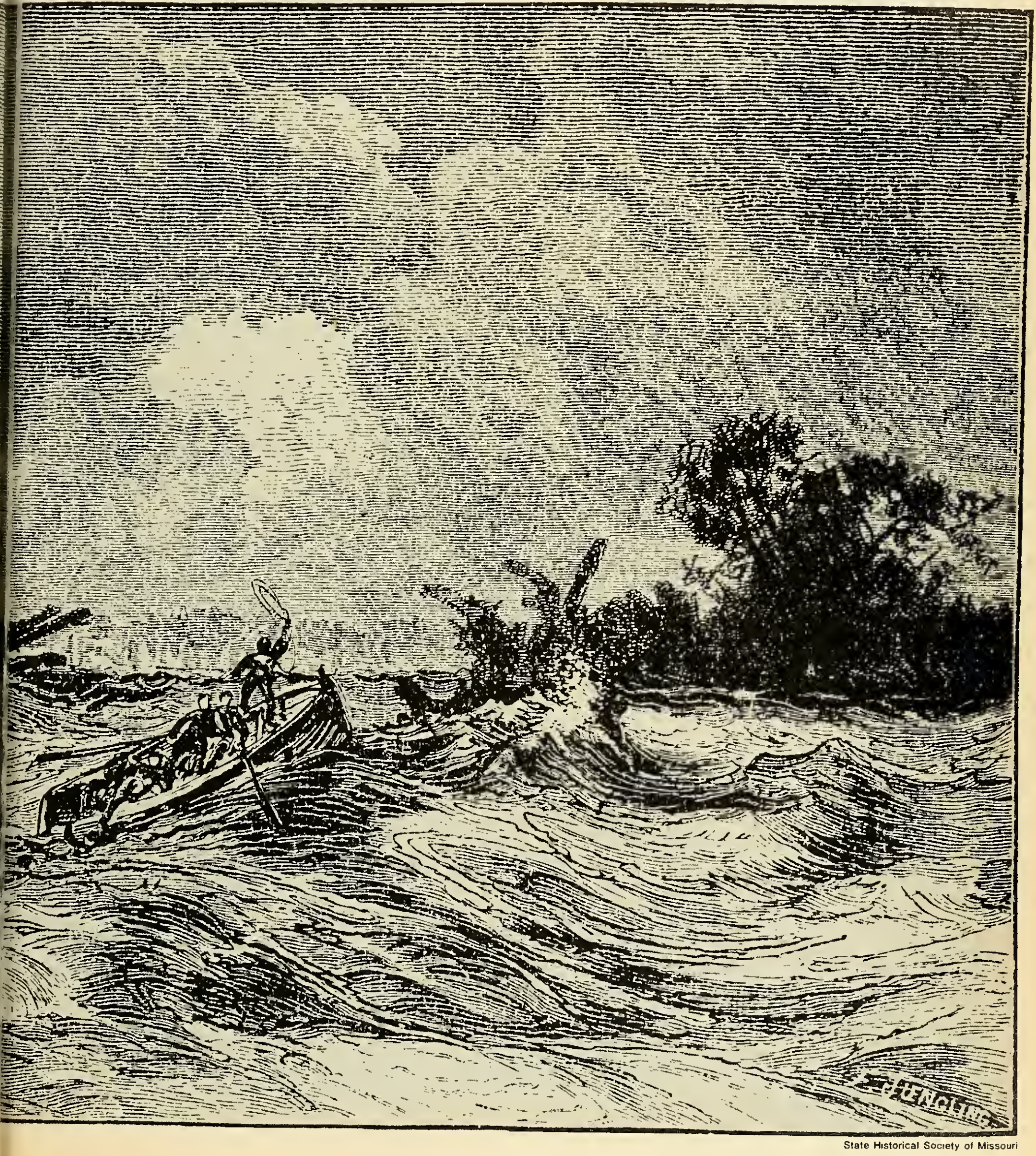
The most severely affected stretch of the Mississippi River was thinly populated at the time of the earthquakes. New Madrid, Missouri, perched above a sweeping bend in the river, was the main settlement in the region. In 1810, about 3,165 people lived in the area, which later became New Madrid County. Only a few of the settlers died, but hundreds of people were traveling or transporting goods on the river when the shocks struck, and casualties on the water may have been more numerous than on the land, although no reliable estimates are known.

The earthquakes virtually destroyed New Madrid. Most of the structures were tumbled by the first tremors, and the site of the town sank fifteen feet. The awesome effects on the land and the aftershocks, which continued intermittently for more than a year, so demoralized the inhabitants that many abandoned the area.

We have scant reliable information about the New Madrid earthquakes. The shocks predate the late-nineteenth-century development of the

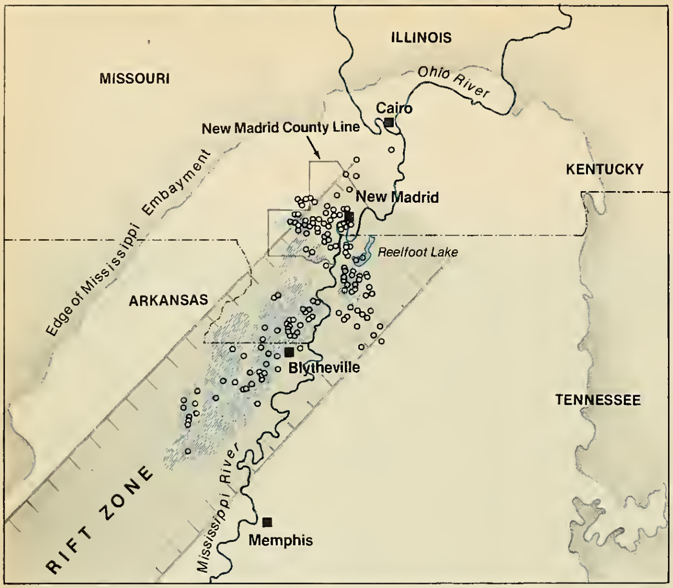


*The Mississippi River during the 1811–1812 earthquakes as depicted in a nineteenth-century book.*



State Historical Society of Missouri

**Rift Structure in the New Madrid Area**



Joe LeMonnier

*Light blue areas indicate regions where sand was ejected onto the land surface during the 1811–12 earthquakes. Sand distribution is part of the data showing the location of those shocks. No primary surface faulting was associated with them. Circles show epicenters of earthquakes in the last few years. The exact boundaries of the Rift Zone are not known.*

seismograph, the instrument for recording earthquakes. Even without instrumental data, however, we can estimate the magnitude of the earthquakes on the Richter scale by comparing the size of the areas affected with those of modern earthquakes. Such a comparison indicates that the three strongest quakes were between 7 and 7.5 in magnitude. Earthquakes of magnitude 6 or greater in populated areas are usually destructive. For example, the earthquake that caused severe damage at San Fernando, California, in 1971 was of magnitude 6.4.

Much of what we know about the effects of the New Madrid earthquakes comes from fragmentary accounts of inhabitants and travelers in the area when the quakes struck and of scientists and naturalists traveling through the area before the effects eroded away or were otherwise obscured. Among the distinguished observers who visited the region were John James Audubon, the famous ornithologist-naturalist, and Sir Charles Lyell, the English geologist whose work on the association of geologic formations with fossils helped pave the way for Darwin's theory of evolution.

The most lasting effects of the earthquakes are the extensive lowlands, or "sunken lands," of northeastern Arkansas, southeastern Missouri, and northwestern Tennessee. Reelfoot Lake, in Tennessee, was enlarged and deepened by the quakes. Consequently, many hardwood and cypress trees died and their stumps can be seen in the lake today. Near Blytheville, Arkansas, an area of more than twenty-five square miles was covered by about three feet of extruded sand that came from deposits less than fifty feet deep. Liquefied by shaking from the earthquakes, the deposits were then ejected through cracks in the clay and silt of the river valley. The ground tremors from the earthquakes were described in vivid terms by those who experienced them, with the sensations being likened to the final cataclysm as the ground heaved and ruptured.

The cause of the New Madrid earthquakes has been a major seismological mystery. Most of the world's earthquakes take place where the large plates of rock that constitute the earth's outer shell separate, scrape past each other, or collide. These plates, which are a maximum of about fifty miles thick, float on the hot, partially molten interior of the earth in much the same way that solidified rock floats in a lava lake in the crater of a volcano or that ice sheets float on water. But the plates are vastly greater in size and their rate of movement is very slow (on the order of a few inches a year). In contrast to earthquakes in California and Alaska, which are known to result from the scraping and colliding of the Pacific and the North American plates, the New Madrid earthquakes took place well within the North American plate, where relatively little splitting of the continent has taken place in geologically recent time.

Important clues have recently been uncovered that suggest a solution to the mystery of the New Madrid earthquakes. Teams of government and university scientists have used new techniques, as well as some that have been employed in oil prospecting for more than a decade, to compile a convincing array of revealing data. The source of the New Madrid earthquakes now appears to be a deep break in the North American plate, referred to as a rift, that formed at least 500 million years ago. This rift extends all the way through the crust, to depths of more than twenty-five miles. Occasionally, the highly stressed continental rocks slip suddenly along this weak zone, shaking the ground intensely in an earthquake.

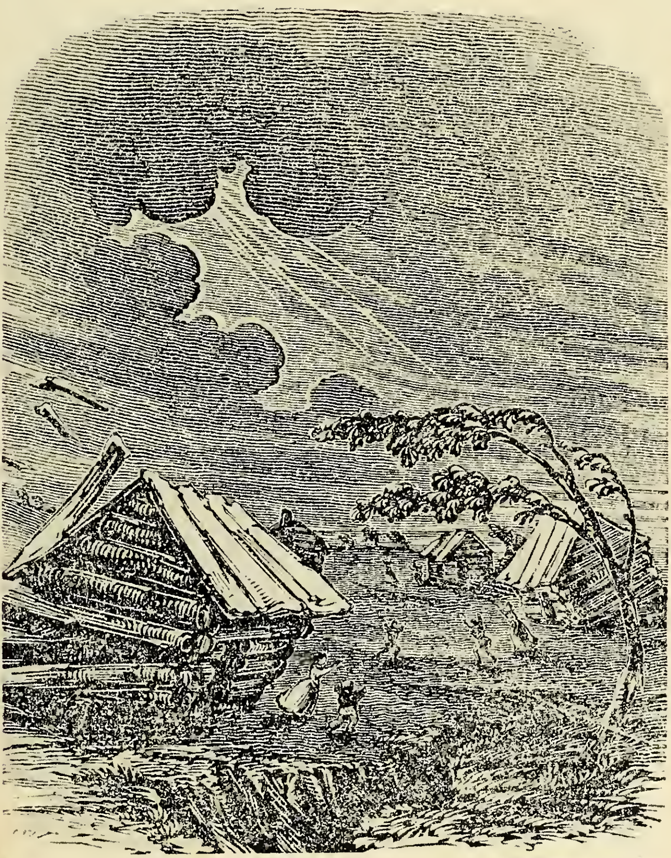
The importance of understanding the cause of the New Madrid earthquakes lies in the realization that sooner or later similarly strong earthquakes will strike again in the same region. The geologic forces causing earthquakes in the New Madrid area, or anywhere for that matter, are associated with the forces that build mountains and drive the plates. They are consequently of a long-term nature. The general characteristics of seismicity persist for time intervals measured in millions of years.

An appreciation of the potential damage of earthquakes in the New Madrid region can be gained by considering the area affected by the

11–12 tremors, particularly in comparison with other great United States earthquakes. Residents of Washington, D.C., at a distance of 750 miles, clearly felt the New Madrid earthquakes—doors and windows rattled, chandeliers swung. In Boston, about 1,000 miles away, church bells rang from the shocks. The earthquakes were also distinctly experienced in Charleston, South Carolina, where a somewhat smaller but similarly widely felt earthquake occurred in 1886.

The vast areas affected by these eastern earthquakes contrast sharply with the much smaller areas affected by large western earthquakes. For example, the 1906 San Francisco and 1964 Alaskan earthquakes, both greater than magnitude 8 on the Richter scale, were felt no more than a few hundred miles away. This difference in area affected is caused by the more rapid dying out of seismic waves in the West compared with the East, presumably owing to differences in crustal structure and the presence of hotter rock at depth in the West.

The new information about the cause of the New Madrid earthquakes has been derived in the last five years, largely as a result of intensified studies aimed at evaluating the earthquake threat in quake-prone areas of the United States. Earthquake studies in the New Madrid seismic region are hampered by the nature of the geologic setting. The area lies at the northern end of a major geologic structure known as the Mississippi Embayment. The embayment is a downwarped trough of hard Paleozoic rocks filled with relatively soft rocks ranging in age from about 100 million years to recent times. These soft rocks, mostly sandstone and clay, were deposited while the embayment was sinking. Because the rocks are soft, the geologic record of long-term fault movement is not well preserved; therefore the nature of faulting in the embayment in relation to that in the surrounding region is difficult to determine. The soft sediments of the embayment effectively veil the deep earthquake-related geologic features and necessitate the use of expensive, sophisticated geophysical methods that can "see" through the sediments to basement rock.



*Period woodcut of New Madrid quakes.*

State Historical Society of Missouri

A moderately dense network of sixteen seismograph stations, operated in the New Madrid region by Saint Louis University, provided important new information. Seismograph stations are used for determining the source location, or focus, of earthquakes. The point on the earth's surface above the focus is called the epicenter. The more stations there are in a seismic area, the more accurately the epicenters can be determined.

Before installation of the dense seismograph network, the seismicity pattern appeared diffuse, like the scatter of holes from a shotgun blast. The improved location accuracy of the dense network brought a welcome surprise: the diffuse pattern of epicenters was resolved into a few linear zones of seismicity. The linear nature of the zones revealed the approximate location of the earthquake-causing faults. Other data gleaned from the seismograph stations showed the direction of slip on these faults.

Surveys of the magnetic and gravitational fields in the New Madrid region by scientists of the U.S. Geological Survey and Purdue University provided additional clues. The hard Paleozoic sedimentary rocks of the Mississippi Embayment have had many igneous rocks intruded into them. The igneous rocks came from great depths, were injected into the sedimentary rocks as molten masses of various shapes, and then cooled. These intrusive masses, called plutons, are denser and more magnetic than the surrounding rock, which is mostly limestone and dolomite, so they cause strong anomalies in the gravity and magnetic field. Where the plutons are more deeply buried, the anomalies are less sharply defined than anomalies caused by plutons close to the surface.

The surveys revealed a band of relatively weak anomalies cutting north-

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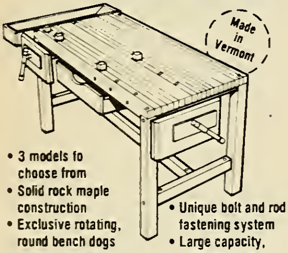

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eastward across the seismic zone. It is inferred that this band corresponds to a downdropped block of the shallow crust that slipped to a position about a mile lower than its original position, analogous to the way the keystone in an arch would drop if the supporting columns were moved apart.

The downdropped block delineated by the magnetic and gravity data is known in geologic terms as a rift. Such a feature can form where molten rock penetrates the lower crust, causing uplift and stretching of the upper crust. Numerous faults are formed as a result, and blocks of the extended crust collapse to form the rift. The main zone of seismicity in the New Madrid region is coincident with the middle of the rift, indicating that the weakest part of the rift is along its axis.

The first information on the detailed structure of the rocks in the seismic region was provided by a technique much used in the search for petroleum, but little used in earthquake studies because of its cost. Known as seismic-reflection profiling, the technique is basically very simple.

Seismic waves are generated at the land surface either by explosions or, more commonly these days, by vibrating pads mounted on trucks. The waves propagate downward into the crust, and as each layer of rock is encountered, part of the wave energy bounces back. Along the ground, a line of instruments called geophones, which sense ground vibrations, is deployed from the trucks to a distance of about a mile to detect the returning energy and to record the precise time of its arrival. The elapsed time between sending and receiving the wave energy, together with information about wave velocity through the rocks, yields an estimate of the depth of each reflecting layer. By combining data from many vibration points, we can construct a picture that shows the approximate configuration of rock strata beneath the survey line. In effect, what we have is a cross section of the earth's crust that resembles a slice of layer cake.

Thus, seismic-reflection profiling makes it possible to map the configuration of rock strata deep in the crust and to delineate faults and folded strata that may be associated with earthquakes. In 1978 and 1979, extensive profiling, along about 170 miles of lines, was done in the New Madrid region with impressive results.

A major fault zone, coincident with the main zone of seismicity, was found below the soft sediments. This fault zone is probably the source of at least two of the three largest shocks that took place in 1811–12. Strata across the fault zone are arched and faulted, much as would be expected from continental rifting. Most of this deformation occurred about 300 million years ago, but there is clear evidence of more recent faulting in the rift structure.

In addition, a northeast-trending set of faults was found that appears to have moved substantially in geologically recent time. The youngest strata seen are vertically offset by about 250 feet. This fault movement, which certainly took place during the last 50 million years, the age of the youngest beds seen to be disrupted, could have occurred entirely within the last few thousand years.

The zones of faulting found by seismic-reflection profiling lie along the rift axis, where the main seismic zone also falls. Plutons, the intrusive masses of molten rock, likewise are present along the rift axis. Their presence indicates that the faulting extends through the crust and serves as a conduit for the molten rock.

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Piecing these fragments of information together, we can reconstruct a skeletal geologic history of the northern Mississippi Embayment. Before about 500 million years ago, geologic forces caused uplift of a large area of the Central Mississippi Valley. The uplift probably resulted from upwelling of magma from deep in the earth's hot interior. It caused the crust of the earth to stretch and break, and large blocks of rock were dropped down in a long zone to form a rift.

From 500 to about 300 million years ago, the rift area was sinking, the sea was encroaching, and thick sediments, first of sand and clay and later of limestone and dolomite, were deposited. Sometime between 300 million and 200 million years ago, the land rose again, the sea withdrew, and much of the accumulated sediment eroded away. While the land was rising, igneous intrusive activity occurred and plutons were emplaced in another stage of rift activity.

As the episode of rifting subsided, the land gradually sank, and by 100 million years ago the sea had once again covered the region. Additional episodes of igneous intrusive activity took place in the embayment about 100 million years ago and possibly again less than 50 million years ago. After this last episode, substantial fault movement occurred, probably associated with minor rifting.

The net result of all this geologic activity is that the earth's crust in the embayment is badly weakened. The embayment is, therefore, a place where the crust breaks repeatedly as the stresses associated with movement of the plates bring pressure to bear.

A natural question to ask is, When will a strong earthquake again strike the New Madrid region? The answer is we don't know because earthquake prediction is not yet reliable even in the best-studied areas, such as California, and relatively little work has been undertaken toward prediction in the New Madrid region. Nevertheless, evidence indicates that, on the average, strong earthquakes strike the region about every 600 years. Of course, several such shocks could strike in a short time span, followed by a long period of inactivity. In terms of planning, the best policy is to recognize the inevitability of future, damaging earthquakes in the New Madrid region and to incorporate earthquake resistance in the design and construction of important structures. ☐

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# Celestial Events

by Thomas D. Nicholson

**The Moon** The moon is a morning object in early August and September, rising after dark and setting in daylight. The evening crescent appears just before the middle of each month, and from then until the last week the moon is up at sundown, brightening the early night. August phases are: last-quarter on the 3rd, new on the 10th, first-quarter on the 18th, and full on the 25th. Last-quarter appears again on the 1st of September, new moon on the 9th, first-quarter on the 17th, and full (the harvest moon) on the 24th.

**Stars and Planets** Venus is a spectacular morning star in August and September, rising about 3½ hours before the sun and visible in the east until daylight. It is the only planet well placed for viewing in these months. Mercury moves from Gemini through Cancer into Leo in August and into Virgo in early September. Venus spends time in five constellations. Starting from Taurus and with a brief stay in Orion, Venus is in Gemini most of August and in Cancer most of September but moves into Leo late in that month. Mars is in Virgo; Jupiter and Saturn are in Leo in August but move into Virgo in September; Uranus is in Libra; Neptune is in Ophiuchus; and Pluto is in Bootes.

August 5: The star near the crescent moon at dawn this morning is Aldebaran, in Taurus.

August 6–7: The moon will be close to Venus at dawn on these days.

August 10: Today there is a partial solar eclipse in the southwestern and southern United States, and in Central and South America. It is an annular eclipse along the central line in central South America.

August 10–14: These are the mornings (from 1:00 A.M. on) to look for the Perseid meteor shower, the most reliable and productive (50 meteors per hour at maximum) of the year. The shower will be best on the 12th, but a good shower (25 or more per hour) should be visible on other mornings.

August 12–13: You may just be able to see Jupiter and Saturn on these evenings if you can see the crescent moon in the west after sundown.

August 15: Look for Mars, not very bright, near the moon tonight. The planet is just north of Spica, the bright star of Virgo, passing the star on the 17th.

August 24: Venus is at its maximum distance to the sun's right (greatest westerly elongation), placing it in a most favorable position as a morning star.

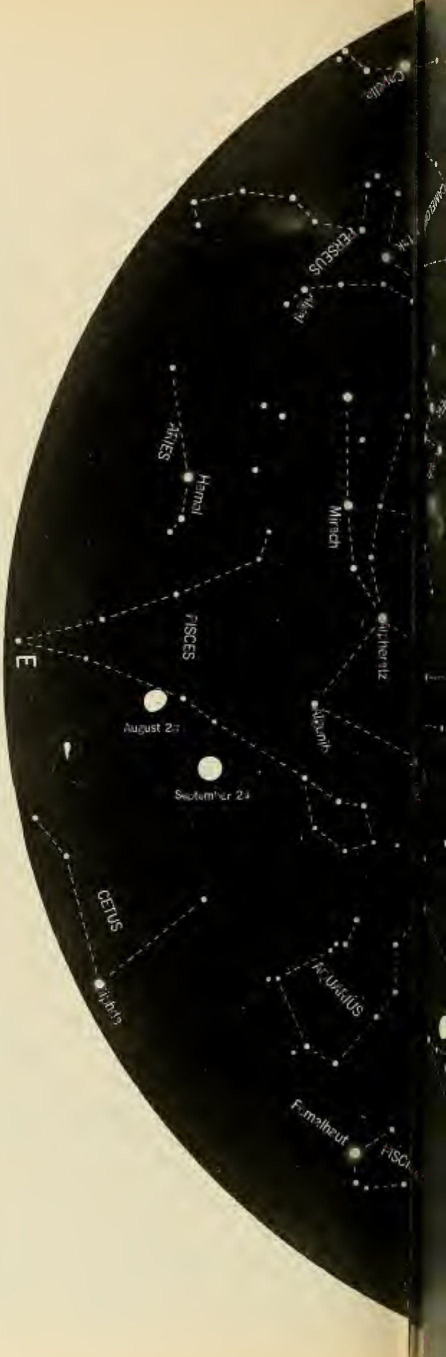
August 25: A penumbral lunar eclipse will produce a barely perceptible dimming of the full moon early tonight.

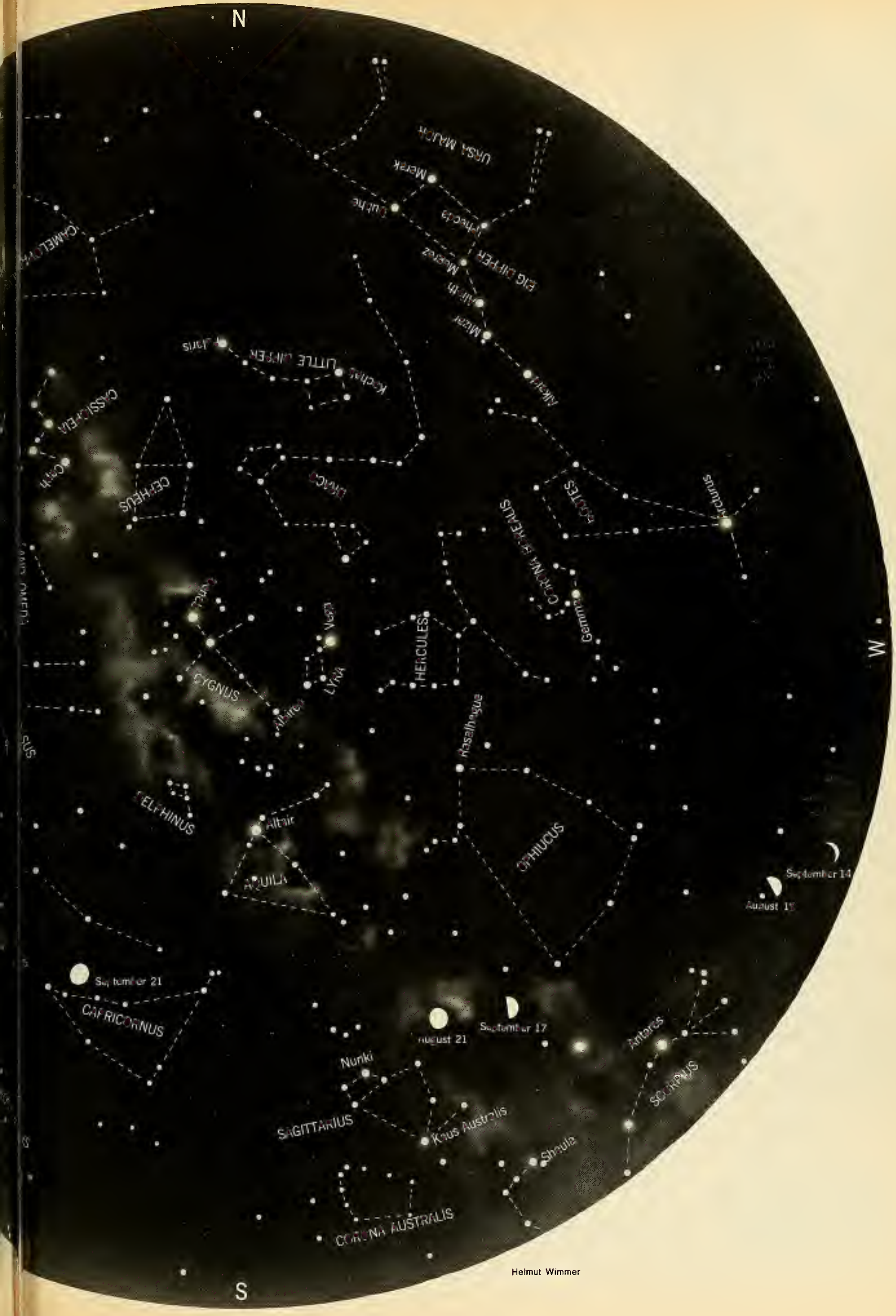
August 26: Mercury, in superior conjunction, becomes an evening star.

September 5: Be sure to see the very close conjunction of the moon and Venus this morning (an occultation elsewhere).

September 13: Jupiter, in conjunction with the sun, becomes a morning star. The moon is near Mars this evening.

**Evening Star Map** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those in the sky. When you face the other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match the stars in the sky with those on the lower half of the map. The map represents the sky at about 11–12 P.M. on August 1; 10–11 P.M. on August 15; 9–10 P.M. on August 31; and 8–9 P.M. on September 15. It shows only planets and moon phases above the horizon at those times, and all times are EST.

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# Galactic Go-around

*The material in spiral galaxies does not move in the manner astronomers expected*

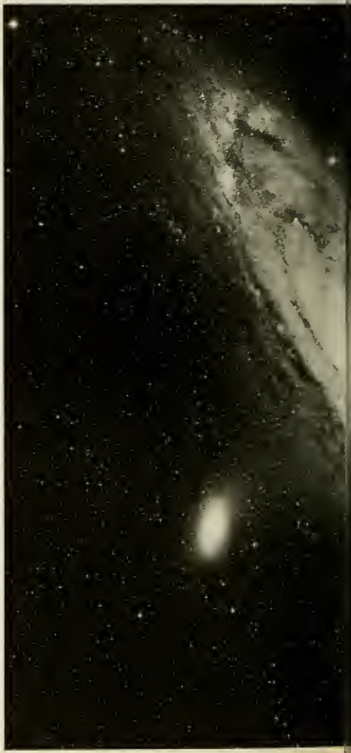
**by Vera C. Rubin**

When you look up at the sky on a dark night in the Northern Hemisphere, all of the stars you see with the naked eye are members of our galaxy, the Milky Way. These stars are all gravitationally bound and rotate about a common center. Most have orbits that lie close to the same plane that contains our sun. Looking out through this plane we see projected on the sky the light from those stars in the form of the luminous band we call the Milky Way. (This band is in fact only a part of the galaxy.)

The plane of the Milky Way is home to many objects besides single stars. In addition to our solar system with its swarms of comets, it holds double stars, clusters of stars, tenuous clouds of atomic hydrogen, and dense clouds of molecules containing hydrogen, oxygen, carbon, and other elements, as well as dust. In cocoonlike manner, these dense clouds surround the birthplaces of stars. Also in the plane of the Milky Way are planetary nebulae—the outer envelopes of glowing gas that have been shed by aging stars as they mature—and remnants of supernovae, gas shells, wisps, filaments, neutron stars, and pulsars.

The supernovae are the objects that complete and initiate the life cycles in our galaxy. Having transformed all of the hydrogen and helium in their cores to heavier elements as their fuel, these stars end their lives by exploding and thereby returning to the interstellar medium the elements heavier than the hydrogen and helium from which they formed. New generations of stars, their birth initiated by the compression of the interstellar gases into dense clumps by the shock waves from the supernovae, restart the cosmic life cycle.

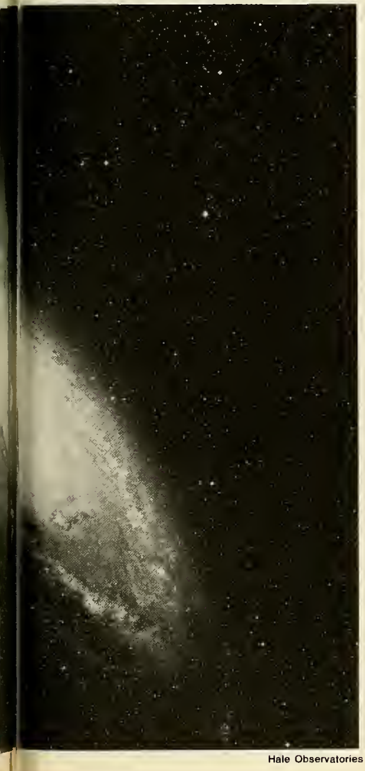
Our galaxy is, of course, not alone in space. There are probably more galaxies in the universe than there are stars in the Milky Way. If you live in the Southern Hemisphere, two satellite galaxies of the Milky Way are a familiar sight in the night sky. They



*The Andromeda galaxy, also known as M31, is a spiral galaxy like our own.*

are the Large and Small Magellanic Clouds (See *Natural History,* June/July 1979), small irregular galaxies gravitationally bound to ours and probably in the process of disruption or perhaps merger with us due to the tidal pull from our greater mass. We know these objects are galaxies because they have the usual galaxy population of stars, star clusters, hydrogen gas, molecules, supernovae remnants, and pulsars.

At distances greater than the Magellanic Clouds, our galactic neighborhood is populated by about twenty known galaxies. These are generally small, globular, and of low mass. Together with our galaxy and the Magellanic Clouds, they constitute an assemblage known as the Local Group. One of our nearest neighbors, the Andromeda galaxy, or M31, and our own galaxy contain most of the mass of the Local Group, and most of the smaller galaxies are clustered within a few million light-years of one of these two large galaxies.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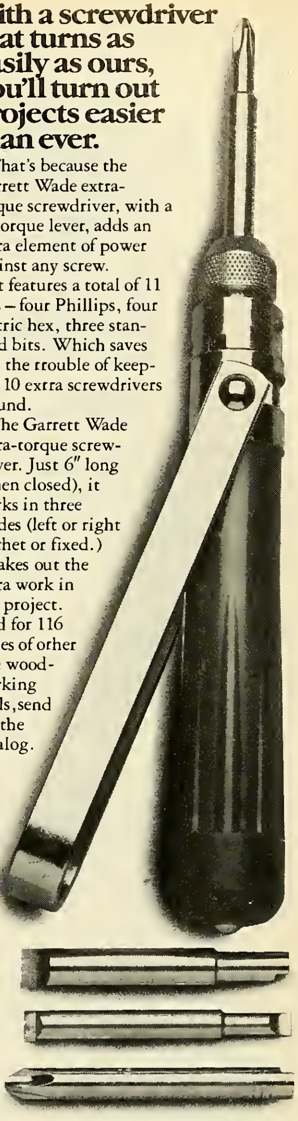
Throughout the universe at large, two main classes of galaxies have been identified—spirals and ellipticals. The spiral galaxies, like our galaxy and Andromeda, have their light concentrated to a plane, and their prominent spiral structure is delineated by a population of bright, young, hot massive blue stars and gas. The elliptical galaxies, of either spheroidal or elliptical outline, are devoid of any noticeable structure or gas content. Elliptical galaxies occur in an enormous range of sizes and luminosities, from giant ellipticals in cores of clusters of galaxies, to dwarf ellipticals, often the companions of larger galaxies.

Astronomers have recently established that the morphology of a galaxy is related to its environment. Giant ellipticals are found preferentially in regions of high mass density, such as centers of rich clusters and groups, while spiral galaxies preferentially inhabit lower mass regions, such as the outer parts of clusters, and are isolated in the general field. The density of our own Local Group of galaxies is only slightly enhanced over the average density of galaxies.

What are the mutual motions of galaxies in the Local Group? Although we know very little at present, we do know that M31 and our galaxy are



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approaching each other. The smaller galaxies are presumed to be in orbit around M31 or around us, moving through circular orbits at great distances or, more likely, through elongated elliptical orbits that take them near our galaxy at their closest approach and to large distances at the most remote part of their orbits. Apparently, the density of matter within the Local Group is sufficient to counteract the expansion of the universe, for there is no evidence that the Local Group is expanding.

The Local Group is one of the outlying aggregates of the Virgo Supercluster, a flattened group of galaxies centered on the Virgo cluster of galaxies at a distance of fifty million light-years from us. Are Supercluster members rotating about the Virgo cluster? Possibly, but probably not. Is the density here sufficient to slow down the expansion of the universe? Possibly. These are difficult questions to answer observationally, and the evidence is still being gathered. Real understanding of these gigantic structures of clusters of galaxies will be fundamental to our understanding the universe.

Beyond the Virgo Supercluster lies the region that Edwin P. Hubble, the American astronomer who studied and classified numerous galaxies beyond the Milky Way, called the Realm of the Nebulae. This region has galaxies in all directions as far as the telescope eye can see—single, double, multiple, clusters, and clusters of clusters. Some galaxies contain as few as one million stars, some as many as a million million. But each one is a dynamical entity held together by the mutual attraction of its stars until approached by a more massive neighbor. When that happens, some galaxies will orbit, some collide, some tear out enormous tails, some lose their outermost stars to the larger galaxy, or—most catastrophic—some will be devoured entirely and form part of a new dynamical entity.

In this garden of galaxies, the internal motions we understand best at present are those of the normal spiral galaxies such as the Milky Way and M31. Our knowledge comes from the study of the spectra of these stellar systems. Although each galaxy is gigantic by terrestrial measuring units, all are so far away that they appear tiny in the sky.

By means of a large telescope and a spectrograph, the light from a galaxy can be dispersed into its component colors (like a rainbow), upon which are superposed bright lines emitted by the excited gas in the galaxy. Because of the systematic internal motions of the stars and gas, these lines are displaced from their normal laboratory position. Light from that part of the galaxy that is rotating away from us is shifted to the red region of the spectrum and light from that part of the galaxy that is turning toward us moves toward the blue. From detailed spectroscopic studies of spirals of various types, a picture has emerged that will fit a spiral galaxy much like our own, one with a radius of about 100,000 light-years, and a mass of about several hundred billion stars.

At the center of such a galaxy is a massive nucleus, whose properties are still somewhat elusive. It could be a black hole, that is, a mass equivalent to some ten million suns in a region as small as a few miles across, or it could be just a giant star cluster of a million stars. Near the center of the galaxy the stellar motions have a circular component, but there are also large-scale structures with motions inward or outward from the center. Energetic phenomena we barely understand are accelerating large masses of material to high velocities, as well as producing radio frequency and X-ray emission.

Beyond a few thousand light-years from the center, the stars and gas settle down to an orderly rotation about the center, with rotational velocities near 300 miles per second. In the solar system, most of the mass is at the center, the sun; and the outer planets therefore move more slowly than the inner ones. In a normal spiral galaxy such as the Milky Way, however, the outer stars orbit with speeds just as great as those of stars near the center. This observation, which came as a surprise, has great implications for the distribution of mass in spiral galaxies and means that most of the mass is not concentrated at the center. In a spiral galaxy, there is significant mass at large distances from the nucleus.

To understand this interpretation, it is necessary to start with the law of gravitation. Newton was the first to understand that the gravitational pull between two objects decreases as the square of the distance between them. If two bodies increase their separation by a factor of two, their mutual attraction goes down by a factor of four. For planets orbiting a sun containing almost all of the solar system mass, this means that outer planets feel a smaller gravitational acceleration, and hence orbit with smaller velocities. Mercury, with a solar distance of 0.39 astronomical units, or AU (an AU equals the distance from the sun to the earth, 93,000,000 miles), moves with a velocity of about thirty miles per second; Pluto, 100 times farther away with a distance of 39.5 AU, moves with a velocity of about three miles per second, only one-tenth that of Mercury.

Astronomers had long expected that in a galaxy, stars at great distances from the nucleus would show low orbital velocities by analogy with the solar system. Thus they were anticipating that most of the mass in a galaxy would be in its nucleus. However, recent observations contradict this expectation. High orbital velocities at large nuclear distances mean that the mass is more uniformly distributed in a galaxy than in a solar system. In fact, for some spiral galaxies, the velocities of stars actually increase the closer they are to the outer edge of the optical image.

This forces us to adopt a new model for the distribution of mass in a spiral galaxy, a model in which the total quantity of matter increases rapidly as the radius increases. Because the mass continues to increase, even at the edge of the optical galaxy, we conclude that there must be significant matter beyond the optical image. It is this unseen mass that keeps the orbital velocities high.

What is the nature of this mass? It cannot be highly luminous or we would see it. It could consist of millions of very faint stars, each with a very low amount of matter, or cool objects that are more planetlike than starlike, or perhaps mini black holes. While the unseen mass might be a flattened disk like the optically visible galaxy, it might, alternatively, envelop the galaxy like a giant halo. How far would such a halo extend? Astronomers are only now attempting to probe such questions using several techniques—observations in the infrared region of the spectrum where cool stars would radiate and observations of rotations in the bulges and halos of distant galaxies. A third method involves the detection of absorption lines from hot gas clouds in the halo of our own galaxy that are superimposed on the spectrum of stars in a neighboring galaxy such as the Magellanic Clouds.

These observations of the outer regions of distant spirals have forced us to reexamine our ideas of the structure of our galaxy. The conventional model of our galaxy places the sun 25,000 light-years from the center, at about two-thirds of the distance to the edge. It also predicts that stars located at greater distances from the center than the sun will orbit with slower velocities.

Prodded by the observations of other galaxies, astronomers have now detected young stars and dust well beyond the solar orbit, whose velocities indicate no decrease in orbital velocity (actually they show a slight increase). Moreover, observations of the hydrogen emission toward the outer edge of the galaxy and of the velocities of the small satellite galaxies at very large nuclear distances suggest that these objects, too, have high orbital velocities in response to the extended mass of our galaxy. There is now every reason to believe that our galaxy has a radius of about 150,000 rather than 50,000 light-years and that the sun is therefore not out in the galactic suburbs.

We do not yet know how far our galaxy extends. An upper limit to its extent must be halfway to the Andromeda galaxy, one million light-years, for if it extended farther, our outer envelope would meet the outer envelope of that galaxy. Theoretical arguments show that two galaxies with interacting envelopes will merge into one composite object in a time as short as the revolution of one galaxy around the other—some hundreds of millions of years. But the presence of so many double galaxies in the universe makes it unlikely that most galaxies have halos extending to their nearest neighbors.

A vast assortment of observational equipment—optical, radio, infrared, X-ray, gamma-ray, and ultraviolet telescopes—is currently being used to investigate galactic structure and dynamics. Progress is rapid in many directions. But as in all good problems, solutions to some parts just raise additional questions to be answered.

*Vera C. Rubin, an astronomer on the staff of the Department of Terrestrial Magnetism at the Carnegie Institution of Washington, specializes in the structure and motion of galaxies.*

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# Other Faces

### by Herbert R. Harvey

Mexican Masks, by Donald Cordry. *University of Texas Press, $39.95; 280 pp., illus.*

A correlate of modernization in Mexico has been a sharp decline in the production of folk art. Some forms of folk artistic expression have all but disappeared in many localities where, just a few years ago, they were prominent and embedded in the current of daily life. One example is the mask, an important ceremonial accouterment of indigenous Mexico for more than three millenniums.

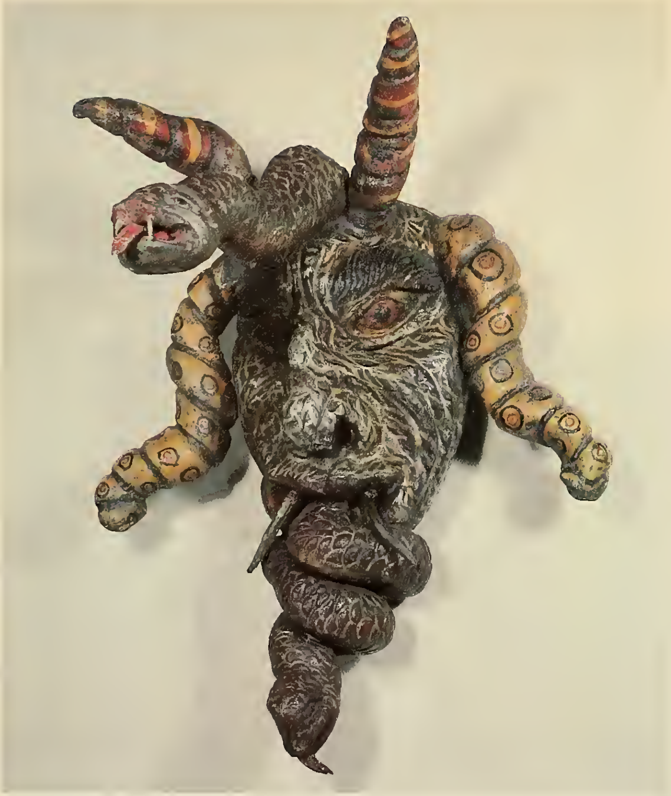
From 1931 until his death in 1978, Donald Cordry, together with his wife, Dorothy, conducted numerous ethnographic investigations throughout Mexico, paying special attention to masks—their use and manufacture, their meaning and significance in the culturally conservative peasant and Indian communities. The results are presented in *Mexican Masks,* the only comprehensive work on this colorful and intriguing expression of Mexican popular art.

This fine volume is beautifully illustrated with more than two hundred color and eighty-five black-and-white photographs, twenty-eight line drawings, and two maps. The majority of photographs are from Cordry's own collection, part of the documentation he built up during forty years of fieldwork. As Peter Furst points out in his introduction to the volume, Cordry possessed the skill of a professional photographer, and his photographs of villages, dances, mask makers, and materials are as important a part of the record as are the field notes and the masks themselves. Without ethnographic context, the masks would lose much of their significance. During field trips, the author systematically collected masks, often under the auspices of such institutions as the Museum of the American Indian and Mexico's National Museum of Anthropology, whose collections he helped to build. At the same time he formed his own private collection, and drew on it extensively for his analysis. It is probably not an exaggeration to say that Donald Cordry had a more profound knowledge of Mexican masks than any other person before or during his time. A successful artist and designer, he brought the sensitivity of his vocation to bear on his avocation.

But *Mexican Masks* is not merely a book of pictures. Rather, it preserves an important balance between descriptive analysis and relevant illustration. The text covers a broad range of subject matter, including the art and iconography of masks, their making and their use. Whenever possible, the author has tried to provide historical context in his discussion. Interestingly, very few masks of great age have survived. In part, this reflects the perishable nature of the materials: paper, wax, leather, even wood. Another reason for the scarcity of old masks is that age alone does not engender reverence for a mask. The lore associated with a particular mask tends not to survive the immediate generations of its maker and owner. Cordry noted that when an old mask occasionally

*Indian soldier mask, Dance of the Battle of the Fifth of May*

*Twin masks, Dance of the Twins*



*Devil mask, dance unknown*

turned up, it often held little meaning for the community or even for those who had kept it in their possession. Thus, many questions about specific masks, such as the origin or intended meaning of a motif or the implication of spatial or temporal stylistic variation, often cannot be answered with any degree of certainty. One of the virtues of the book is that it raises as many provocative questions as it answers and presents a solid point of departure for future research on masks and masked dances.

From the earliest manifestations of civilization in Mesoamerica, masks have played an important role in native religion. There is considerable archeological evidence of their use, and they are depicted in native pictorial codices. Early colonial observers of native culture also made occasional reference to masks. Major pre-Hispanic deities, such as Tlaloc (Lord of the Rain) and Quetzalcoatl-Ehecatl (Lord of the Wind), were depicted as masks. In religious ceremonies, priests serving as masked dancers would become one with the deities whose masks they wore. This transformation was an essential concept in pre-Hispanic religion.

Although it has deep roots in ancient Mexico, modern mask use in ritual performance is also the product of Spanish and, to a lesser extent, African influence. Some aspects of native religion were abhorrent to Spanish missionaries—human sacrifice, for example, and the depiction of Indian deities, who were considered to be demons. But the Spaniards did not suppress the use of masks. On the contrary, they introduced their own masks, reflective of their religious concepts and symbols, which sometimes replaced but more often fused with native ideas. New façades in the guise of Christian personages protected old ideas. Cordry points out, for example, that native deities had both good and bad aspects but that Catholicism tended to concentrate evil in a single personage, the Devil. Indian societies adapted to Spanish imagery by adding horns to their demons. Today devil masks are among the most common and widespread types, but they still often contain iconographic elements common to native cultures. Tigers, butterflies, serpents, frogs, lizards, various birds, and other animal motifs seem more closely linked to native tradition than to external influence.

In general, mask usage today is most prevalent in western Mexico, from the Yaqui and Mayo communities in the northwest, south through the states of Michoacán and Guerrero. But masked dances are also somewhat common in the states of Puebla, Tlaxcala, Oaxaca, and Chiapas. Distribution seems correlated less with linguistic-cultural groupings than with geographical isolation. As the infrastructure of rural roads has increased, masked dances, along with the number of artisans skilled in the craft of mask making, have diminished. Over the decades, Cordry interviewed many mask makers and personally observed the decline in this craft.

Mask makers consist of three types of artisans: the *santero,* who also carves religious statuary; the professional mask maker; and the amateur. To a trained eye, the product of *santeros* can often be distinguished, since *santeros* generally possess more adequate tool kits and greater technical skill. Not surprisingly, there is a tendency for craft production to pass from generation to generation within family lines. The book contains a useful appendix of mask makers, including linguistic and genealogical information, as well as descriptions of tools and mediums customarily used.

There are many and varied ceremonies utilizing masked dancers in traditional Mexican communities. One of the more colorful and widespread groups of masked dances, with roots in sixteenth-century Spanish Catholicism, is that of the Moors (*los Moros*) and Christians. Formerly performed on horseback and often with a large cast of participants, the dance is less pretentious today and is usually performed by a small group of dancers. In this perennial, ritual struggle, a group of dancers representing Christians battle their adversaries, the Moors, until the latter capitulate or are overcome. The dance symbolizes the age-old struggle between Good and Evil, with Good the invariable victor.

Another theme that gained prominence in folk tradition is the Spanish conquest of Mexico. In many of the dances associated with this theme, masked dancers represent such notable figures as Hernán Cortés, the conqueror, and Montezuma, the ill-fated Aztec emperor who lost his life and kingdom in the conquest. Malinche, Cortés's Indian interpreter and mistress, is often portrayed as the betrayer of her people. Such dances recount the destruction of native civilization, a sad event believed to have been redeemed, however, by the advent of Christianity. Other events, such as the Battle of the Fifth of May (1862), have also lingered in folk memory and find occasional expression in dances.

While many dances commemorate identifiable postconquest historical events and Christian personages, others have been performed since antiquity. This is particularly evident in the rain-related group of dances with its propitiation of the Lord of Rain. In a land where drought is an ever present threat to crops, rain-petitioning ceremonies are widespread and their forms and particular modes of expression are rich and varied. Masks used in these ceremonies often contain motifs such as serpents, whose symbolic association with the rain god is of unquestioned antiquity. One of the most fascinating aspects of masks as artistic expression is the variety and manner in which old symbols are interpreted and reinterpreted by mask makers.

Considering the social and technological changes that have taken place in Mexico over the past half century, it would be surprising were they not reflected in the mask tradition. As society has become more secularized, many communities have modified their manner of religious expression. But while some have abandoned their old themes, others have improvised new ones. In addition, regional dances stimulated by government and tourist interest are today more common than in the past, so that the resilient Mexican mask tradition seems to be accommodating itself to a new forum. Future investigators will have a different theater in which to observe the drama, but as it evolves, it may be as rich as the one Cordry found.

*Herbert R. Harvey is a professor in the Department of Anthropology at the University of Wisconsin–Madison.*

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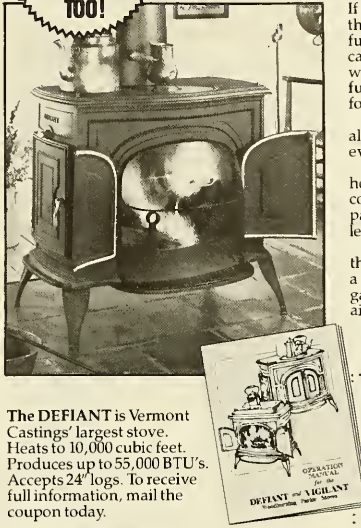

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# Additional Reading

**Eskimo Curlew** (p. 30)

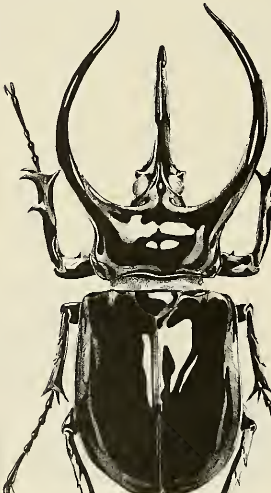
An art book as well as a dependable ornithological reference, *The Shorebirds of North America*, edited by G.D. Stout, with text by P. Matthiessen, paintings by R. V. Clem, and species accounts by R. S. Palmer (New York: Viking Press, 1967), includes information on, and a full-sized color plate of, the Eskimo curlew. A smaller reproduction of this painting can be found in "What to Look For: Eskimo and Little Curlews Compared," by J. Farrand, Jr. This article, along with "Sight Record of Eskimo Curlew (*Numenius borealis*) on West Coast of James Bay, Canada," by J. A. Hagar and K. S. Anderson, and "The Decline and Fall of the Eskimo Curlew, or Why Did the Curlew Go Extaille?" by R. C. Banks, was published in *American Birds* (March 1977). Banks analyzes the decline of the curlew from a new point of view, suggesting that environmental changes contributed more to the curlew's disappearance than previously thought. Two early accounts to which Banks refers are *Life Histories of North American Shore Birds*, by A. C. Bent (*U.S. National Museum Bulletin 146, 1929*), which discusses curlew distribution, biology, and behavior and contains quotes from leading ornithologists of the day, and *The Eskimo Curlew and Its Disappearance*, by M.H. Swenk (*Annual Report of the Smithsonian Institution for the Year Ending June 30, 1915*, pp. 325–40). These reports vehemently claim that overhunting caused the decline of the curlew.

**Horned Beetles** (p.34)

G.J. Arrow of the British Museum (Natural History) devoted his life to the study of beetles, especially horned beetles. His *Horned Beetles* (The Hague: W. Junk, 1951) is a thorough study written for the layman and the scientist. To compare horned beetle behavior and survival with that of other insects, see *Sexual Selection and Reproductive Competition in Insects*, edited by M.S. Blum and N.A. Blum (New York: Academic Press, 1979). *Life on a Little-known Planet*, by H.E. Evans (New York: E.P. Dutton, 1978), is a natural history of insects. In "Horned Beetles," a recent article in *Scientific American* (March 1980, pp. 166–82), W.E. Eberhard explains that beetles use their horns to lift rivals of the same species rather than to stab prey.

**Lakes Baikal and Superior** (p.56)

M. Kozhov's *Lake Baikal and Its Life* (The Hague: W. Junk, 1963), the definitive work on the subject, includes many photographs, tables, and references, briefly reviews the literature about Baikal, and reports on the lake's flora, fauna, geography, and hydrology. Two photographic essays on Baikal and the Siberian countryside are *Ozero Baikal* ("Lake Baikal"), by G.I. Kooka, R. Petera, and E. Varmanyana (Moscow: Soviet Russia Publishers, 1967), and *Vremyena Goda* ("The Four Seasons"), edited by S. Mikhalkov (Moscow: Planeta Publishers, 1978). Lake Baikal has been the subject of magazine articles from time to time—see M.I. Goldman's "The Pollution of Lake Baikal" in the June 19, 1971, issue of *The New Yorker* (pp. 58–66) and R. Chelminski's "Baikal Survives as a Prize for the Whole Planet" (*Smithsonian*, November 1975, pp. 44–51). "Report from Lake Baikal," by S. White (*New Scientist*, August 5, 1976, pp. 275–77), is a status report on pollution in Lake Baikal that includes a special discussion of the Baikalsk cellulose mill. *Lake Baikal Endangered by Pollution*, by P. Nijhoff (*Environmental Conservation*, vol. 6, no. 2, 1979, pp. 111–15), provides an overview. Two large picture books are *Superior: The Haunted Shore*, photographs by B. Litteljohn, text by W. Drew (Toronto: Gage Publishing, 1975), and *The Faces of the Great Lakes*, photographs by B.A. King, text by J. Ela (San Francisco: Sierra Club Books, 1977). The latter illustrates the influence of human activities—cities, industries, fishing, shipping, and mining—on the environment. The story of all the Great Lakes has been told in *The Enduring Great Lakes*, a *Natural History* book edited by J. Rousmaniere (New York: W.W. Norton, 1979).



*Chalcasoma atlas* Daniel Otte

**Urban Plazas** (p.62)

A standard reference for planners, *Death and Life of Great American Cities*, by J. Jacobs (New York: Random House, 1961), was based on direct observations of how people use spaces. J. Jacobs previously contributed a chapter on downtown areas to *Exploding Metropolis*, first published in 1958, by the Editors of Fortune (Westport: Greenwood Press, 1976). In *Personal Space: The Behavioral Basis of Design* (Englewood Cliffs: Prentice-Hall, 1969), R. Sommer discusses human spatial behavior and presents a variety of design concepts for special purposes. E. T. Hall analyzes personal spaces (for example, how close to others people of various cultures can stand without feeling that they are invading another person's privacy) in *The Hidden Dimension* (New York: Doubleday and Co., 1966). In *Streets for People* (New York: Doubleday and Co., 1969), B. Rudofsky speaks unfavorably of American pedestrians. On the other hand, he believes that Italian streets provide many pleasures. For a tour of American cities, see A. Heckscher's *Open Spaces: The Life of American Cities* (New York: Harper and Row, 1978).

**Mississippi Earthquakes** (p. 70)

*The New Madrid Earthquakes of 1811–1812*, by J. Penick, Jr. (Columbia: University of Missouri Press, 1976), a lively account drawn from descriptions published at the time of the quakes, includes woodcuts, maps, sketches, tables, and an eighteen-page guide to further reading. Penick says that "all material relating to the earthquakes that appeared in newspapers from 16 December 1811 through June 1812 is available on a microfiche card attached to Otto W. Nuttli's article, 'The Mississippi Valley Earthquakes of 1811 and 1812: Intensities, Ground Motion and Magnitudes,' *Bulletin of the Seismological Society of America* 63 (February 1973), 227–28." *Continents in Motion: The New Earth Debate*, by W. Sullivan (New York: McGraw-Hill Book Co., 1974), is an introduction to continental drift and plate tectonics. Each chapter has a long list of further references. Earthquakes are among the topics discussed in *Earth*, second edition, by F. Press and R. Siever (San Francisco: W. H. Freeman, 1978). *Continents Adrift and Continents Aground: Readings from Scientific American* (San Francisco: W. H. Freeman and Co., 1976) contains articles by various authors.

*Katharine D'Agosta*

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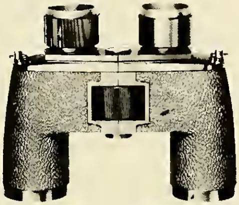

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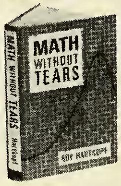

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# Polyester Dinosaurs

Tucked away in the labyrinthine complex of the American Museum of Natural History's twenty-two buildings is a squat, cement-and-brick shed identified simply as the Reproductions Studio. Inside, two staff members and numerous volunteers are busy casting life-sized replicas of some of the massive dinosaur skeletons in the Museum's collection. The skeletons were ordered by various science and natural history museums, which for between $150 and $13,000 will have an exact reproduction of one of the Museum's superb saurian fossils.

The interior of the studio is as remarkable as the outside is dull. The rib cage of a triceratops, huge enough for two people to walk around in, rests on plywood mounts near the entrance. Its freshly cast head sits upside down on a table, and its massive leg bones are stacked like cordwood against the wall. Nearby, technicians are assembling a second triceratops that will eventually be shipped to Saudi Arabia for a multimillion-dollar science and technology museum. Several other unfinished dinosaur skeletons lie in untidy heaps of gray polyester ribs and sections of vertebrae. Other assorted items in various stages of reproduction include fifteen reconstructed heads of prehistoric man, several tracodont (duck-billed) dinosaur skulls, a mold-in-process of the code of Hammurabi, a pile of claw bones, leg bones, foot bones, and rib cages of lycaenops (a mammallike reptile), and several monkey masks from Indonesia.

Martin Cassidy and his assistant, Jeanne Kelly, who operate the studio, are at the top of their highly select profession. Cassidy, with Kelly's help, developed the complex techniques needed to duplicate in plastic the enormous skeletons, although Kelly had not had any formal training in casting before coming to the Museum six years ago.

Cassidy began working in the Museum's Department of Vertebrate Paleontology many years ago, making molds and casts of such things as teeth, small bones, and other fossils for scientific study. "I started experimenting," he says, "using both known and new tooling methods." He spent much of his free time fooling around with molds, with the indulgence of the department. As his techniques became increasingly sophisticated, he was able to cast larger and more complicated skeletons, and other museums began asking for material that was previously unavailable. Finally, the director moved him out of Vertebrate Paleontology and gave him a studio of his own in the Department of Exhibition and Graphics. Shortly after that the Natural History Museum in Osaka, Japan, asked for a complete *Stegosaurus* skeleton, Cassidy's first big job.

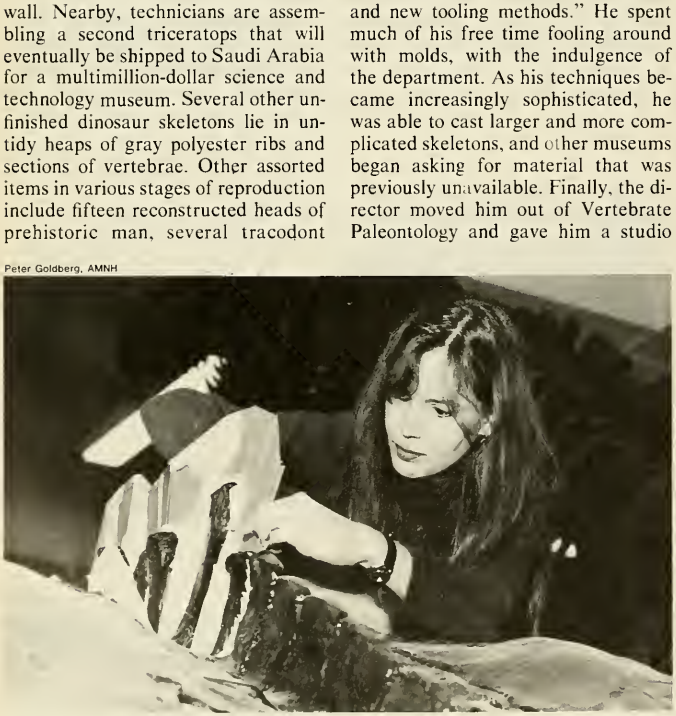
In the field of mold making, which is increasingly reliant on computer technology and the assembly line, Cassidy is a craftsman who knows how to work with his hands. Each skeleton is entirely handmade, and the complex ones may take up to one and a half years to finish. The most sophisticated equipment in the studio is a pair of rebuilt drills that Cassidy picked up on Canal Street for $10. "We try as much as possible," he says, "to modify and adapt existing material and equipment. We mine the Museum's dump for its treasures—scrap metal, wood, packing material. Sometimes just to look at the dump gives us ideas."

The triceratops is their latest skeleton—and their most ambitious. It is more than twenty-three feet long, and its skull alone measures six by four by six feet. The replica required 125 molds, more than 150 gallons of latex, nearly 200 gallons of polyester resin, and in excess of 2,000 hours of work.

Cassidy and Kelly began on the triceratops about two years ago; this summer, they finished two of the four reproductions on order. Their first step was to completely overhaul the skeleton, which had been on display since the 1920s. Because of its weight, all work on the original took place in the Hall of Late Dinosaurs where visitors could watch the action. One side benefit of working in public was that Cassidy drew a steady pool of volunteers from interested spectators, including a Broadway actress, a retired manufacturer of wedding rings, and a talented fourteen-year-old who could roll out a perfectly symmetrical six-foot clay cylinder.

The reproductions team disarticulated parts of the skeleton, repaired damaged areas, cleaned it, and replaced the old plaster reconstructions with fiberglass. Once the triceratops was in top-notch shape, they began marking literally hundreds of reference points on the bones; this information would later appear in the casts.

Peter Goldberg, AMNH



*Working in the Hall of Late Dinosaurs, Jeanne Kelly prepares a backbone section of the massive triceratops skeleton for casting.*

Cassidy also invented and built from scrap wood a contraption he calls a "rib locating and holding jig." The jig, which looks a bit like a porcupine, was built inside the original rib cage and acts as a template for re-creating the exact configuration of the ribs in the duplicate. "That's always the biggest problem," says Cassidy. "We had a hard time with the stegosaurus when we tried operating from photos. The way we've set it up now, anyone could put that skeleton together."

In the next step of casting, they carefully looked at the topology of the bones to decide where each mold should go. Each mold was poured in latex and held in a stiff fiberglass jacket, which reproduced every detail in the original, including the nuts and bolts used to hold the skeleton together. The completed molds were carried back to the studio for casting. A mixture of fiberglass and polyester resin, dyed the approximate color of the original, was used to re-create each bone or grouping of bones. After sanding, staining, and reassembling, the first facsimile was ready for shipment to its new home.

With the growing market for paleontological reproductions, the studio publishes yearly a price list of available casts. The triceratops "ready for mounting" is a mere $13,200. One can also purchase a stegosaurus ($10,450), a four-foot ankylosaurus tail club ($220), a fossil ichthyosaur with young inside ($522), a three-toed merychippus ($1,650), assorted dinosaur footprints ($192.50 and up), and a restored head of Peking man ($137.50). If you don't find what you want on the list, you can always ask. "This is not a commercial operation," says Cassidy. "We offer a service to museums around the world and schedule our prices simply to recover all costs relating to the studio's operation."

To date only museums have ordered skeletons, but Cassidy will sell to anyone willing to put up the money. He would like to see some of New York's downtown office buildings set up some of his castings in their lobbies; they would, after all, be cheaper than most modern sculpture. "There is a lot of interest in these forms as sculpture; bones frequently are a primary metaphor for many artists," he says.

The success of the studio has, of course, been accompanied by a proliferation of molds, which are stored in an adjoining shed. In this unheated space, lit by a single, naked light bulb, negative images of everything from the Aztec Calendar Stone to a *Tyrannosaurus rex* jaw share space with the Museum's snowplow and electric carts. And every year the shelves get more crowded.

A question that both Cassidy and Kelly are often asked is what exactly their job is called. "Paleontological sculptor?" says Kelly. "Too much of a tongue twister. It's hard to say what it is, but I love it." After pausing a few seconds, she adds, "It's what I grew up to be."

*Douglas J. Preston*

**Chinese Puppeteers**

Eleven puppeteers from the People's Republic of China will be giving four performances at the Museum on September 4 through 7 as part of a U.S. tour under the sponsorship of the Asia Society's Performing Arts Program. This troupe performs traditional plays that have been passed down from father to son for generations. The puppets fly through the air, spin plates on their heads, and pour their own cups of tea. The puppets are on tour in the United States for the first time, and this will be their only appearance in New York. For ticket information, write to the Membership Office of the Museum.

**Course for Stargazers**

The Hayden Planetarium offers a wide range of courses on meteorology, astronomy, telescope making, flying, and celestial navigation. A free course catalog and registration form can be obtained by writing to the Hayden Planetarium.

**Grasslands Giant**

*The African Elephant*, a film by naturalist Simon Trevor, will be shown at the August members' program, Wednesday, August 6, at 7:30 P.M. in the Auditorium. The film features scenes of the social behavior, feeding, rearing, mating, and death of the elephant, but it also includes footage of a cheetah stalking its prey, a newborn wildebeest taking its first steps, and flamingos flying over a lake in the Great Rift Valley. The program is free for members, $3.00 for nonmembers.

**Ravi Shankar**

Ravi Shankar, renowned sitarist and composer, will give a lecture-demonstration in the Museum Auditorium on Wednesday, September 10, at 7:00 P.M. Tickets for the evening are $6 ($5 for members) and may be obtained in advance by sending a check to the Department of Education at the Museum.

**Egypt Dances**

A special two-evening series on the dance of Egypt will be presented by the Education Department of the Museum on Wednesday and Thursday, August 20 and 21. Magda Saleh, former prima ballerina with the Cairo Ballet, will introduce and narrate her film, *Egypt Dances*, for the program on Wednesday evening. On Thursday, Walter Terry will comment on three dances that Saleh will perform. Series tickets for the two evenings can be obtained by sending $10 ($8 for members) to the Department of Education at the Museum.

**Museum Highlights Tours**

For veteran museumgoers as well as new visitors, the Museum offers free tours of its most interesting halls and exhibits. The *Museum Highlights Tours* leave on a regular basis from the second floor Information Desk. Check about specific times on the day of your visit.

**Discovery Tours**

The Museum is offering an art and archeology tour of the People's Republic of China in October 1980. Twenty-four participants will join Prof. C. Bruce Hunter for an in-depth visit to archeological and historical sites in Peking, Shanghai, Kwangchow, and other cities. At present, this popular tour is filled, but the Museum is planning similar tours for the spring and fall of 1981. This is just one of the many tours offered by the Museum to its members and friends. For information and itineraries, write to Discovery Tours at the Museum.

# Hot Cajun Sausage

Boudin, *a fiery, pale-colored food speciality, is an important part of Louisiana's Acadian culture*

**by Raymond Sokolov**

Dudley Hebert stirred the big pot with a short-handled canoe paddle, gently prodding thirty-five pounds of pork and pork innards, while they cooked almost to the point of disintegration. Standing in the improvised kitchen at Arceneaux Park in Broussard, Louisiana, some little children and adults watched as he ground that meat and mixed it with rice and lots of red pepper. Then he showed them how to stuff this "rice dressing" into sausage casings. Mr. Hebert and his collaborator, Elmer Girouard, used a hollow, open-ended cow horn to do the stuffing. The horn once belonged to Mr. Girouard's grandfather, who had always used it to stuff sausage on his farm in southwestern Louisiana, when he and his family slaughtered hogs in the preserving cold of a winter day and processed every shred of the animal, from head to hock. Being Cajuns, they spoke French, and called this gala pork butchering event a *boucherie.* And the loose sausage they made—a fiery, pale-colored specialty with a strong taste of liver and kidney—they called *boudin blanc.* Traditional Cajun *boudin blanc* can still be found in Cajun country. Indeed, last February in Broussard, it was impossible to avoid.

Broussard is somewhere in-between being a drab, post-Depression farm center and a suburb of bustling Lafayette, ten miles to the north. This year the Broussard Jaycees and Jaynes sponsored the second annual Louisiana Boudin Festival. Local *boudin* factories worked overtime to produce thousands of pounds of sausages. Hebert and Girouard did their demonstration. Several young men and women competed in the *boudin*-eating contest, slurping stupendous quantities of pork and rice stuffing out of long, drooping casings.

I myself consumed an immoderate number of *boudins,* warding off the chill of an incessant winter drizzle with their warming spices. I ate *boudins* from all the booths, including a seafood *boudin,* heterodox but delicious. Somewhat bloated with all this gorging, I began to see the justice of an opinion expressed by John Norbert, a professional *boudiniste* at one of the booths. "The secret of a good *boudin,*" he averred, "is seasoning plus more meat than rice."

With these words fresh in mind, I joined forces with *boudin* aficionado, Barry Jean Ancelet, a young and impassioned Cajun folklorist at the University of Southwestern Louisiana in Lafayette, who introduced me to the higher arcana of *boudin* at a nearby supermarket called Dud Breaux's. The pork-rice ratio seemed just about ideal as Ancelet, his family, and I worked our way through a few pounds of sausage hot from the pot at Dud Breaux's. We threw the casings to the Ancelet dog and launched into the vexed question of Cajun culture.

The *boudin* is a spongy but natural platform from which to rise to the larger issue of Cajun identity and survival because *boudin*—ungainly, wildly spiced, and messy to eat—has become part of the stereotype of the Cajun in our time.

"Cajun" itself is an emblem of cultural misunderstanding, corrupted from the French *Acadien,* the name given to French settlers driven out of Nova Scotia (then called Acadia) in 1753. As they made their way south, an unfriendly Anglophone North America dubbed them Cajuns. Arriving in southwestern Louisiana's malaria-infested bayous and isolated lowlands about 1765, they found a refuge where they could carry on peacefully as an ignored, French-speaking majority. "They were the melting pot here," says Barry Ancelet. "They were the mainstream society. All through the nineteenth century, other groups came in and adopted French, people with names like Johnson, Segura, and Schneider. The original Cajuns were not immigrants to the United States. They were here before there was a United States. My grandmother objected when a nephew of hers married *'une americaine.'*

"As late as the turn of the century, Cajun culture was all there was around here. Hell, everyone was eating *boudin.* Then the Anglo-American world began to press in. Oil was found in Jennings, at the so-called Evangeline field. (I really resent the whole Evangeline business, having the rest of the world learn about us through that poem. Longfellow never met a Cajun. And he wrote in English.) Oil brought in a money economy and an English-speaking population. Then the mandatory education act established a school

system that forced our kids to learn English. And World War I took a whole generation of Cajuns away from home, where they saw for the first time that they were a minority. The mass media finished the job of putting our culture in danger, by providing slick programming that was much better than anything coming from here. People began to feel their culture was low class, something to leave behind."

With all these external pressures on them, it was no wonder that many Cajuns fled into assimilation or as far away as they could from the traditional life of the Cajun "coonass," a local pejorative probably drawn from the French slang term *conasse*, meaning a stupid person or, as Vaughan Burdin Baker puts it in the Junior League of Lafayette's Cajun cookbook, *Talk About Good,* "an ignorant and superstitious individual speaking ungrammatical and thickly accented English, eating *boudin* and two-stepping to a cacophonous accordion."

Currently, Ancelet estimates that there are about one million French-speaking people in Louisiana, of whom only one-third to one-half use French primarily. This is a sharp decline from the 100 percent of a few decades ago. But there are counterforces at work. Cajun music has undergone a serious revival. French, albeit standard French, is now promoted officially in local schools. And the University of Southwestern Louisiana fosters Cajun traditions through the Center for Acadian and Creole Folklore, which employs Barry Ancelet, who is militantly at work trying to foment a literary and cultural renaissance conducted in the dialect of his forebears.

Food plays no small part in Ancelet's plans. Cajun food is especially threatened by outside influences. The homogenizing forces of American agriculture and corporate food production compete with Cajun rural cuisine, just as they do with every American food tradition rooted in the folkways of oldtime farm life. In a world of supermarket meat departments, the Cajun *boucherie*, once a focal point of Cajun communal existence, now happens only here and there, and just rarely enough so that people turn out for a staged hog slaughtering just as they would for a special event.

Perhaps the Louisiana Boudin Festival itself is a sign of incipient decline. No figures exist for comparing *boudin* consumption today with its consumption fifty years ago. But it is safe to say that *boudin*, more than any other feature of Cajun life, apart from the French language, symbolizes the French-speaking community of Louisiana and its complicated, imperiled identity. When you taste a *boudin*

photographs by Adelaide de Menil

*A sausage-stuffing machine with stringlike hog casing attached to its nozzle; the casing is long and part has already been filled with* boudin blanc.

*blanc,* you know you have come into contact with Cajun culture, unapologetic and unlike anything else.

Well, not quite. Like Cajun French, the Cajun *boudin* has firm roots in France. The heavy amount of rice in the stuffing reflects the overwhelming traditional local commitment to rice as a crop, and the powerful spice in the Cajun *boudin* may bring tears to the eyes of French visitors; but those same visitors can undoubtedly lay claim to a paler but older recipe for a recognizably similar *boudin blanc.*

Indeed, the roots of the *boudin* go very deep, right to the bedrock of European civilization. The etymology of the word is not altogether certain, but it probably derives from a Latin word for sausage, *botulus*. The philosopher Seneca speaks, in a letter, of a *botularius,* a "sausage seller." And our word *botulism* is the name of a lethal disease first demonstrably caused by infected sausages.

*The Larousse Gastronomique,* with its usual certitude, declares that the *boudin* is a sausage consisting of a hog's large intestine filled with hog's blood. In English, we would call this concoction (which *Larousse* fancifully ascribes to the cuisine of ancient Assyria) a blood pudding.

It takes no great leap of phonological imagination to see the bond between *pudding* and *boudin.* They sound somewhat alike, and they both originally referred to sausages that had to be cooked so that their stuffing would solidify and become edible. Our modern sense of pudding developed because dessert puddings used to be boiled in casinglike bags. In England, the practice still continues.

In France (which somewhat later received the word *pouding* as a loan from England to describe molded desserts such as English plum pudding) *boudin* retained its original sense of blood sausage, but extended it to include a sausage of minced pork meat mixed with egg and cream, then poached until the eggs firmed up the stuffing. This is the most probable ancestor of the Cajuns' *boudin blanc.*

But if Cajuns carry on this secondary tradition of white *boudin,* what happened to the primary one, the pseudo-Assyrian blood pudding still so popular in modern France when grilled and accompanied with sautéed apple rings or mashed potatoes? Barry Ancelet thought the Cajun version of this, called *boudin rouge*, had died out completely. But at least one enterprising food retailer, LeBouef's of Broussard, still produces Cajun blood pudding on a daily basis in a sausage factory tucked away behind a big conventional American supermarket.

The LeBouef family opened shop many years ago as a *boudin* and crackling store. The current Mrs. LeBouef's grandmother made the sausage at home. Today, the LeBouefs have their own abattoir a short drive from the market, where they slaughter all kinds of meat for their butcher department. And so they are in a position to collect fresh blood legally for *boudin rouge.* Pork blood is too hard to keep free from hairs, so they use veal blood; this satisfies the meat inspector but isn't, in theory, as tasty.

On a typical day at the *boudin* factory behind LeBouef's supermarket, Jacques Benjamin, a French-speaking black, finished up his day's work on several hundred pounds of white *boudin* and turned his attention to the red. Wearing an orange apron, he poured two gallons of blood and cooked rice and seasonings, pork fat, and a scoopful of cayenne into his sausage-stuffing machine. The little room was filled with a haze of red pepper. Tripping the motor switch, he babied a casing as it filled and turned dark purple. He knotted and twisted it into a string of resilient sausages and then started another casing. Eventually, he completed the batch and put it in a pot of water to poach for a half hour, testing for doneness by poking through the skins with a toothpick. By the time he was done, a crowd of workmen and truck drivers were lined up outside at the meat counter to buy their lunch. Hot *boudin blanc,* hot *boudin rouge.* Hot enough to make a Frenchman cry. Hot enough to make a Cajun weep for joy. (See recipe on page 96.)

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

*Jacques Benjamin adds a scoopful of cayenne pepper to* boudin *stuffing.*

*In preparing* boudin rouge, *casing ends are twisted and knotted to form individual sausages.*

## Cajun Boudin Blanc

2½ pounds boneless fresh pork, butt, or shoulder
¾ pound pork liver
¼ pound pork kidney
Salt
2 cups long-grain white rice
2 tablespoons butter
1 large onion, peeled and coarsely chopped
2 bunches scallions, chopped
1 handful parsley
Black pepper
2 teaspoons cayenne pepper
3 yards small sausage casing, approximately (see note)

1. Cook pork, pork liver, and pork kidney in lightly salted boiling water to cover until meat falls apart, about 2 hours. Reserve the meats and the broth.
2. Meanwhile combine rice, butter, 2 teaspoons salt, and 4 cups of water in a heavy saucepan. Bring to a boil, stir once, cover, reduce heat to low, and cook for 15 minutes. Empty rice into a bowl and reserve.
3. Grind the reserved meats, onion, scallions, and parsley together in a meat grinder, using the coarse blade, or grind coarsely in a processor, using the metal blade.
4. Mix the ground meat mixture with the rice, black pepper to taste, salt to taste, and the cayenne pepper. Add the cayenne gradually. The amount recommended may be impractically torrid for non-Cajuns, although it is ethnographically correct.
5. Mix in enough of the reserved broth to make the stuffing moist but not soggy.
6. Rinse the casings to leach out the salt they are preserved in. Cut them into 20-inch lengths with a scissors.
7. If you have a traditional metal sausage-stuffing "horn" or an attachment for a mixer or meat grinder, any one of them will work well for this recipe. Even a large household funnel will suffice. Work one end of the casing over the tube. Then pull on the rest of the casing in a series of folds. It is not necessary to knot the casing. Merely press the free end of the casing and pull it an inch or so off the tube. Then push the stuffing through the tube into the casing, which with some assistance from you, will pull off the tube as it fills. When the casing is filled (with an inch of free space at either end), twist the ends and set aside. Continue until all stuffing is used up. Prick the casings here and there to release any trapped air. The filling is dense enough so that only minor amounts of filling, if any at all, will leak out during the final cooking.
8. *Boudins blancs* are usually served steamed. In other words, heat up a batch in barely simmering water and serve. Eat them by holding the casing in your hands and sucking the insides from the casing. Discard emptied casings.

Yield: About 8 servings

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FESTIVAL
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Note: For $10 postpaid, casings are available from Standard Casings, 121 Spring St., New York, N.Y. 10012, in 100-yard hanks that keep almost indefinitely under refrigeration. Paprikas Weiss, 1546 Second Ave., New York, N.Y. 10028, will mail syringe-like sausage horns for $35.00 postpaid.

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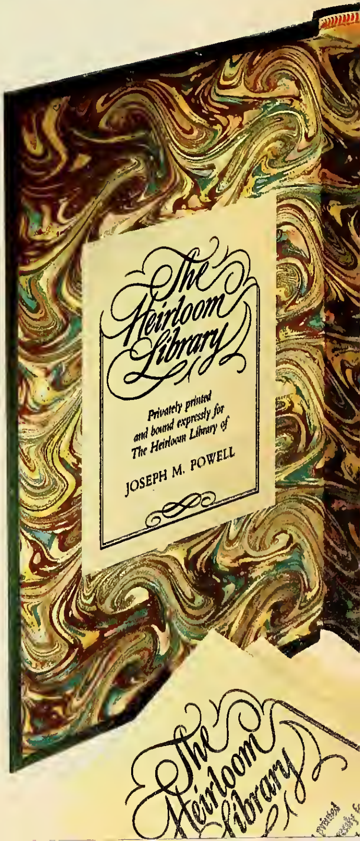
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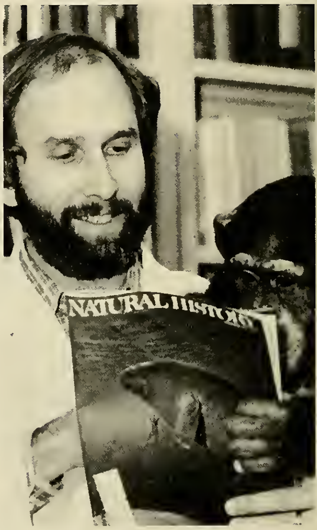

"I became interested in the behavior of the pygmy chimpanzee," says **Randall Susman,** "as a result of studies that showed their anatomy to be different from that of their close relative, the so-called common chimpanzee. I wanted to find a behavioral explanation for the observed anatomical differences." Susman did his chimpanzee fieldwork in Zaire. Other research that engages his attention includes the functional and comparative anatomy of apes and humans, experimental studies of ape locomotion, and the anatomy of fossil humans. An assistant professor of anatomy, Susman is a member of the primatology research group in the Department of Anatomical Sciences at SUNY, Stony Brook, N.Y. He received his Ph.D. in anthropology from the University of Chicago in 1976.

On a raft trip down the Colorado River in 1969, **Jim I. Mead** met Paul S. Martin of the University of Arizona, who introduced him to the study of fossils in the Grand Canyon and their use in reconstructing past environments. Mead went on to excavate numerous caves in the canyon, with a particular emphasis on fossil pack rat middens. Analyses of these remains have provided a much clearer picture of the Grand Canyon's faunal and floral history than previously existed. Mead, a Ph.D. candidate in geosciences at the University of Arizona, is now searching caves in the Grand Canyon area for remains of the extinct Harrington's mountain goat. In his spare time, he collects mammal and reptile skeletons to add to his comparative osteological collection.

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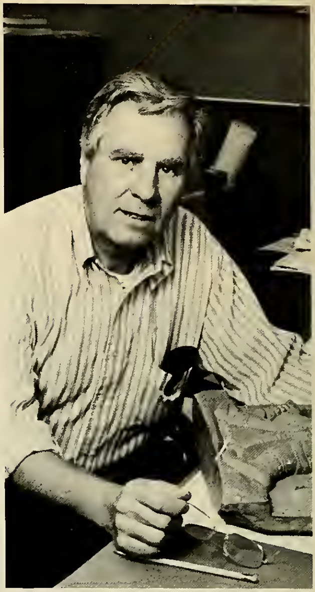
"My maternal grandfather was an importer and lived for a time in China. The house I grew up in was always filled with Asian objects and that may account for my lifetime interest in Asia and the Near East," says **Walter A. Fairservis, Jr.** An archeologist and anthropologist, who teaches at Vassar College and is concurrently a research associate at the American Museum of Natural History, Fairservis made his first field trip at the age of 16, when he ran away from school to see Egypt and India. He joined the American Museum initially as a volunteer in 1941. Among the many expeditions he has led for the Museum since then were several to Afghanistan and Pakistan, and later to Egypt. Fairservis is the scientific consultant for the Museum's new Gardner D. Stout Hall of Asian Peoples. He has written several books and many journal articles on anthropology and Old World archeology.



From the time he was a teenager, **Lee Boltin** knew that he wanted to be a photographer. He developed his art in the Photography Department of the American Museum of Natural History, where he stayed for twelve years. In 1955 he left the Museum to free-lance as a photographer of art objects, working in museums and with private collections. His speciality has been a passport that has taken him around the world and given him access to the treasures of museums in at least fifteen different countries. Boltin has illustrated about 25 or 30 books and catalogs. Among recently issued volumes using his photographs are *The Nelson A. Rockefeller Collection, Masterpieces of Primitive Art* (1978) and *Gold of El Dorado* (1979). Boltin's photographs will also appear in an as yet untitled book, based on the late Nelson Rockefeller's private collection of twentieth-century art.

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## A Night in the Day of a Pest-Control Researcher

Stephen C. Frantz

Stephen C. Frantz's article "Rats in the Granary" (February 1976) grew out of his research in India where he spent his nights in warehouses, letting the lesser bandicoot rats he was studying climb over his lap on their way to the rice. Frantz has stuck with rats, but he is now director of the New York State Health Department's Rodent Control Evaluation Laboratory in Troy, N.Y. The laboratory's primary work is studying the genetic resistance of rats to certain kinds of rodenticides. Frantz has not entirely abandoned nocturnal adventures, however. Last summer he began a study of garbage.

The way garbage is handled is of prime concern in any kind of pest control because garbage is such an important food source for pests. Frantz wanted to find out when people put out their garbage, how much they put out, what they put it in, and how garbage collectors handle it. He and his coworkers began observing and interviewing garbage collectors, going out at night to observe people putting their garbage out, and surreptitiously weighing the garbage.

For this last task, a group of researchers wearing white suits would go out in an unmarked van between midnight and 5:00 A.M., pull up in front of a house or apartment building, take all the garbage, weigh it in the van, and then put it back. The group was on occasion bothered by the police and suffered the shouts and yells of a few outraged garbage owners, but at least, says Frantz, "nobody shot at us." The garbage study is still under way, and one of the probable next steps is a qualitative analysis of the garbage, not how much, but *what* people throw out.

## Panhandling Bears of the Smokies

Why do bears panhandle food from tourists? Because the technique works. In fact, bears, or at least black bears in Great Smoky Mountains National Park, have a success rate that puts human panhandlers to shame. Michael R. Pelton, who wrote "Black Bears of the Smokies" with Gordon M. Burghardt (January 1976), went on to direct a three-year study of panhandling bears and found that in 301 sessions, involving 33 different bears and countless tourists, the bears never went away empty-pawed.

Supervised by Pelton, the study was carried out by Jane Tate, one of his graduate students in the ecology program of the University of Tennessee's Department of Forestry, Wildlife and Fisheries. For three summers (1976–78) Tate observed, filmed, videotaped, and photographed human–bear interactions along a main road that runs through the park. The picture that emerged showed that there were eleven "professional" panhandling bears seen in more than fifteen sessions and

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twenty-two occasional beggars that appeared in less than fifteen sessions. (A session sometimes involved more than one bear.)

The bears were more aggressive than human panhandlers. In 44 percent of the sessions a bear exhibited what the observers considered an aggressive act—anything from a low moan to a charge complete with biting and scratching. But the bears did not seem to have any serious damage in mind. Of 624 acts of aggression (some sessions included more than one act), only 37 resulted in physical contact between a bear and a person, and the bear's bites and scratches broke the skin in a third of those cases. There were no serious injuries.

In some cases the bears showed astonishing restraint. One bear being pestered by two teen-age boys, creatures known to test the limits of human patience, grabbed one of the boys from behind, held him in a classic "bear hug" with its jaws around his neck and then threw him to the ground. When the observers ran to his side, says Pelton, they found "there wasn't a scratch on him."

The information gathered by Tate was presented to the National Park Service in a preliminary report designed to provide information for educating tourists in their dealings with bears. The humans, says Pelton, invariably provoke the bears' aggressive actions. First of all, it is illegal to feed the bears, an injunction that is universally disregarded. Beyond that, in 80 percent of the cases where bears reacted aggressively, their reaction was preceded by people petting them, crowding them, or petting and crowding them at the same time. The tourists, however, generally blamed the incidents on the bears.

Pelton did not speculate on what the bears' reactions might be if their panhandling failed.

## P.P.S.

In a May "Postscripts" item on electric currents in lampreys, Lionel F. Jaffe was incorrectly described as being at Yale University. Jaffe is at Purdue University in Indiana. The two other researchers involved in the lamprey work (who are from Yale) traveled to Purdue to conduct experiments in Jaffe's laboratory, using equipment that he developed.

*James Gorman*

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# Vision with a Vengeance

*Most efforts to place ourselves within or outside of nature have been fruitless*

**by Stephen Jay Gould**

When Linnaeus sought to classify all of life in 1758, he called his great work the *Systema Naturae*, the "System of Nature." Biologists of all subsequent generations have flooded the scientific literature with alternative, but equally comprehensive, systems. The content changes, but the passion for building systems remains. Our urge to make sense of the complexity that surrounds us, to put it *all* together, overwhelms our natural caution before such a daunting task.

A curious irony infects this tradition of building comprehensive systems in biology. Biologists present their systems either as necessary truths of superior logic or as ineluctable conclusions drawn from unrivaled powers of observation—in other words, as objective renderings of nature, heretofore unappreciated. In fact, these systems share only one common property—and it is neither objectivity nor superior wisdom. They are, at base, attempts to resolve a (perhaps *the*) cardinal question of intellectual history: What is the role and status of our own species, *Homo sapiens*, in nature and the cosmos?

Systems follow one of two strategies in their attempt to make sense of "man's place in nature," to use T.H. Huxley's phrase. I wrote about one strategy—the picket fence—in my column of February 1980. Such systems devise a pervasive order for the rest of nature, but separate humans alone with a brand of superiority. Thus, Charles Lyell envisaged a world ever churning and changing, but always remaining the same—replacement without improvement. Only man, a recent imposition of moral perfection upon a stable world, broke the pattern of change without progress. A.R. Wallace attributed all features of organisms to the molding power of natural selection—except for one product of divine inspiration: the human brain.

The second strategy in pursuit of the same goal takes an opposite tack, a placement within nature that will make some sense of our lives. This strategy argues for no separation between man and nature at all. These theories of continuity can proceed in either direction, and I shall discuss one recent example of each as representatives of a long tradition of flawed argument. The first view—I shall call it zoocentric—builds general principles from the behavior of other animals and then subsumes humans completely into the rubric because we are, after all and undeniably, animals too. The second view—I shall call it anthropocentric—tries to subsume nature in us by viewing our peculiarities as the goal of life from the start.

Evolutionary theory itself has an appropriately zoocentric core. General principles cannot arise from the behavior of a single species, yet all species, if they have any validity, must conform to the principles. The role of this mild zoocentricity in breaking down the sturdy picket fences that existed before Darwin's time ranks as one of the great events in the history of human thought. But the zoocentric view can be extended too far into a caricature often called the "nothing but" fallacy (humans are "nothing but" animals).

The simplistic accounts of human sociobiology now flooding popular literature embody this overextended version of zoocentrism. Sociobiology is not just any statement that biology, genetics, and evolutionary theory have something to do with human behavior. Sociobiology is a specific theory about the nature of genetic and evolutionary input into human behavior. It rests upon the view that natural selection is a virtually omnipotent architect, constructing organisms part by part as best solutions to problems of life in local environments. It fragments organisms into "traits," explains their existence as a set of best solutions, and argues that each trait is a product of natural selection operating "for" the form or behavior in question. Applied to humans, it must view *specific* behaviors (not just general potentials) as adaptations built by natural selection and rooted in genetic determinants, for natural selection is a theory of genetic change. Thus, we are presented with unproved and unprovable speculations about the adaptive and genetic basis of specific human behaviors: why some (or all) people are aggressive, xenophobic, religious, acquisitive, homosexual, and so on.

Zoocentrism is the primary fallacy of human sociobiology, for it rests on the argument that if behaviors of "lower" animals with simple nervous systems arise as genetic products of natural selection, then human behavior should have a similar basis. Humans are animals too, aren't we? Yes, but animals with a difference. And that difference arises, in part, as a result of enormous flexibility based on the complexity of an oversized brain and the potentially cultural and nongenetic basis of adaptive behaviors—aspects of human construction that debar any zoocentric extrapolation from why some insects eat their mates to murder in human families.

Ironically, the zoocentrism of human sociobiology is often an illusion hiding a precisely opposite mode of reasoning. I argued previously that "objective" systems are often unconscious masquerades that reflect our own prejudices and hopes imposed upon nature. Much of human sociobiology trades upon the idea that if distinctive human behaviors can be found, albeit in rudimentary form, among "lower" animals, then these behaviors must be "natural" in humans too, a product of biological evolution. Sociobiologists are often fooled by misleading external and superficial similarity between behaviors in humans and other animals. They attach human names to what other creatures do and speak of slavery in ants, rape in mallard ducks, and adultery in mountain bluebirds. Since these "traits" now exist among

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"lower" animals, they can be rederived for humans as natural, genetic, and adaptive. But they never did exist outside a human context. If mallard males seem to force physically weaker females to copulate, what possible relationship, beyond meaningless superficial appearance, can such an act have with human rape? No one can argue that the two behaviors are truly homologous—that is, based on the same genes inherited from a common ancestor. If the similarity is meaningful, it can only be analogous—that is, reflecting different evolutionary origins but performing the same biological function. Yet mallard behavior is part of the normal repertoire and seems to have evident utility in increasing the reproductive fitness of males; while human rape is a social pathology rooted in power and powerlessness, not in sex and reproduction.

Is this not mere pedantic grousing? Aren't the human terms a cute, graphic, and acceptable shorthand for what we all recognize as a more complex reality? Not when a colleague describes aggressive responses of male mountain bluebirds toward other males in the vicinity of its nest with these words: "The term 'adultery' is unblushingly employed . . . without quotation marks, as I believe it reflects a true analogy to the human concept . . . . It may also be prophesied that continued application of a similar evolutionary approach will eventually shed considerable light on various human foibles as well."

Such an old story. We hold a mirror to nature and see ourselves and our own prejudices in the glass. Historical examples abound. Aristotle described the large bee that leads the swarm as a "king," and this misidentification of the only sexual female around persisted for nearly two thousand years, at least to an Elizabethan madrigal I sang last week with the lines: "I do love thee as the spring/Or the bees their careful king" (careful, that is, in the old sense of caring, not the modern meaning of cautious). Zoocentric systems fail primarily because they never are what they claim to be. The "objective" animal behavior, under which they subsume human acts, is an imposition of human preferences from the start.

The more venerable, anthropocentric systems at least have the virtue of explicit self-recognition. They take Protagoras seriously in his claim that "man is the measure of all things," and falter only in the hubris of arguing that evolution undertook its elaborate labor of some 3½ billion years only to generate the little twig that we call *Homo sapiens*. Anthropocentric systems have been out of vogue among scientists, at least in England and America, since Darwin's time, but one version enjoyed some spectacular popularity a few years back—the system of a man I discussed in quite a different context last month, the Jesuit priest and distinguished paleontologist Pierre Teilhard de Chardin.

When Teilhard died in 1955, his evolutionary speculations, long suppressed by ecclesiastical authority, saw light, and his best seller, *The Phenomenon of Man*, became a cult book of the 1960s. Teilhard's florid and mystical writing is often more difficult to decipher than his role at Piltdown, but I believe that the general line of his argument can be simply expressed. (A convinced Teilhardian might brand me as a shallow, heartless scientist, unable to appreciate the profundity of Teilhard's vision. But difficult, convoluted writing may simply be fuzzy, not deep. Teilhard's vision is rich in scope and tradition—for it is an old argument clothed in new terminology—but the essence of his position can still be stated with everyday words.)

Teilhard believed that evolution proceeds in a definite and irreversible direction. To grasp the nature of that movement, we do not look back to the origin of life and its physical properties, but to the latest product—to *Homo sapiens* itself. For life has been moving in our direction from the start. The advance of life records an ever increasing domination of spirit over matter. This ineluctable increase in consciousness can be grasped by studying two of its material products: among lower animals, diffuse and simple nervous systems evolve into centralized organs (brains) with subsidiary parts; among higher animals, brains increase in size and complexity throughout evolution. In an autobiographical essay, Teilhard wrote:

> I never really paused for a moment to question the idea that the progressive spiritualization of matter—so clearly demonstrated to me by paleontology—could be anything other, or anything less, than an irreversible process. By its gravitational nature, the universe, I saw, was falling—falling forwards—in the direction of spirit as upon its stable form. In other words, matter was not ultramaterialized as I would at first have believed, but was instead metamorphosed in psyche.

Human evolution is the culmination of this psychic advance. In the anthropocentric vision, life only makes sense in terms of its striving toward man. We are inextricably part of nature because nature has been yearning toward us from the start. In a 1952 manuscript on human socialization, Teilhard stated:

> Human evolution is nothing else but the natural continuation, at a collective level, of the perennial and cumulative process of "psychogenetic" arrangement of matter which we call life. . . . The whole history of mankind has been nothing else (and henceforth it will never be anything else) but an explosive outburst of evergrowing cerebration. . . . Life, if fully understood, is not a freak in the universe—nor man a freak in life. On the contrary, life physically culminates in man, just as energy physically culminates in life.

Since evolution follows a directed path, the tree of life is not a randomly ramifying network, but a bundle of branches, tied by genealogy at their base, diverging during their history, yet always moving in the same basic direction. The energy of matter compels divergence; the force of increasing consciousness imposes a common upward advance. Related species should form a set of *multiple, parallel lineages*, each diverging and adapting to a local environment, but each gaining continually in its spirit/matter ratio. Teilhard wrote in 1922 that "evolution . . . resolves itself into innumerable lines which diverge at such length that they appear parallel."

With the appearance of man, evolution has reached a crux. Spirit has accumulated far enough to reach self-consciousness. Indeed, a new layer has appeared in the earth's concentric structure. Teilhard praised the great Austrian geologist Eduard Suess for introducing the term "biosphere" as an addition to the traditional concentric layers of lithosphere and atmosphere. But consciousness, Teilhard argued, has added yet another layer: "the psychically reflexive human surface . . . the noosphere."

Teilhard describes the noosphere as a physical reality, as a thin and fragile layer, now spread throughout the earth following the emergence of human ancestors from Africa and their subsequent migration to all continents. He wrote in a 1952 manuscript: "Above the old Biosphere there is spread now a 'Noosphere.' As to the material reality of this enormous event, there is nobody who will disagree." In a posthumous essay published four years later, he described the noosphere as "the marvelous sheet of humanized and socialized matter, which, despite its incredible thinness, has to be regarded positively as the most sharply individualized and the most specifically distinct of all the planetary units so far recognized."

The emergence of a noosphere, now so thin and fragile, represents the turning point of universal evolution. Teilhard wrote in 1930:

> The phenomenon of Man represents nothing less than a general transformation of the earth, by the establishment at its surface of a new layer, the thinking layer, more vibrant and more conductive, in a sense, than all metal; more mobile than all fluid; more expansive than all vapor. . . . And what gives this metamorphosis its full grandeur is that it was not produced as a secondary event or a fortuitous accident—but in the form of a turning point essentially foreordained, from the beginning, by the nature of the general evolution of our planet.

Evolution has now reached its halfway point. Heretofore, despite the progressive gain of spirit, matter has dominated and evolutionary lineages, although moving in the same general direction, have constantly diverged. But the noosphere marks the beginning of the dominion of spirit over matter. As spirit gains the upper hand, convergence shall begin. The fragile noosphere shall thicken. The direction of a billion years shall be reversed, and conscious lineages (within *Homo sapiens* at least) will begin to converge as spirit gains rapidly in its sway over matter.

The beginnings of convergence may already be discerned in the process of human socialization. In terms of vulgar mechanics, human cultural evolution may be a process different from Darwinian biological evolution, but both participate in a higher unity as sequential aspects of universal direction. Human socialization, Teilhard writes, has engendered "a vast and specific process of physico-psychical convergency . . . whose sudden appearance and acceleration in the course of the last century is perhaps the most revolutionary event registered so far in human history. . . . The human world is decidedly caught,

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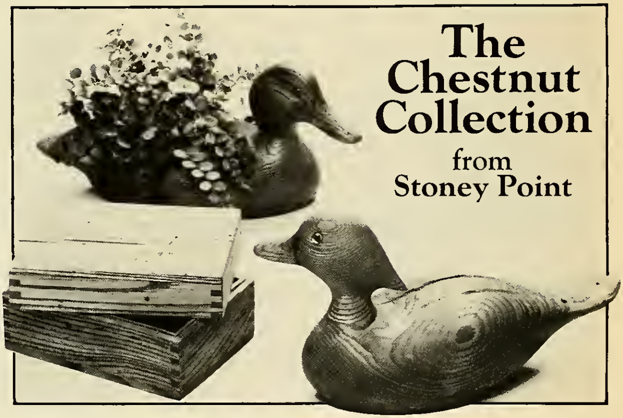

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today and forever, in an irresistibly tightening vortex of unification."

The rush to convergence must concentrate and accelerate until all spirit, freer and freer of encumbering matter, amalgamates at a single point that Teilhard called Omega, identified with God, and, so far as I can tell, viewed as a reality, not a metaphor or symbol. He describes this apotheosis, graphically if not with perfect clarity, in *The Phenomenon of Man*:

> Convergent movement will attain such intensity and such quality that mankind, taken as a whole, will be obliged . . . to reflect upon itself at a single point . . . to abandon its organo-planetary foothold so as to pivot itself on the transcendent center of its increasing concentration. This will be the end and the fulfillment of the spirit of the earth.
>
> The end of the world: the wholesale internal introversion upon itself of the noosphere, which has simultaneously reached the uttermost limit of its complexity and centrality.
>
> The end of the world: the overthrow of equilibrium, detaching the mind, fulfilled at last, from its material matrix, so that it will henceforth rest with all its weight on God-Omega.

And so, evolution labored for billions of years, produced perhaps a hundred million species of plants, bugs, and worms along the way, all to achieve, through the agency of one species endowed with consciousness, the union of its spiritual content with God in splendid concentration at the point Omega. All previous life existed for us and for what *we* could become. Like the floating fetus that embodies the promise of futurity at the close of *2001: A Space Odyssey*, we (or rather our thickening spirit layer, soaring upward) are the heirs and the purpose of all previous life. This is the anthropocentric vision with a vengeance.

What can one say to such a scheme? Would it be too literal and mean spirited to argue that it seems to fail at its only points of testable contact with the fossil record? Few paleontologists can discern any general, much less inevitable, trend to increasing braininess in the history of life. Most animal species are insects, mites, copepods, nematodes, mollusks, and their cousins, and I, at least, can see no pervasive trend among them toward the domination of matter by spirit. And the evolutionary tree does look more to me like a complexly wandering and ramifying bush than a bundle of parallel twigs growing upward in a definite direction. Of course, I realize that Teilhard used the term evolution in a metaphysical sense to identify the laws of cosmic progress, not in our usual sense to specify the mechanics of organic change (which Teilhard recognized and studied, but called *transformisme*). Teilhard's technical works in paleontology are sound and solid, but they deal with *transformisme* and exist in a world of discourse quite separate from his anthropocentric vision of cosmic evolution.

Perhaps the problem with all these visions—zoocentric as well as anthropocentric—is our penchant for building comprehensive and all-encompassing systems in the first place. Maybe they just don't work. Maybe they must be defeated by the inherent complexity and ambiguity of our place in nature. How can we erect a picket fence—and secure one type of vision—when humans are so inextricably bound in nature. But how can we opt for complete continuity, either by working up from other animals (zoocentric) or down from humans (anthropocentric)—and thus secure the other type of vision—when humans are so special, for better or for worse. We are but a tiny twig on a tree that includes at least a million species of animals, but our one great evolutionary invention, consciousness—a natural product of evolution integrated with a bodily frame of no special merit—has transformed the surface of our planet. Gaze upon the land from an airplane window. Has any other species of animal ever left so many visible signs of its relentless presence?

We live in an essential and unresolvable tension between our unity with nature and our dangerous uniqueness. Systems that attempt to place and make sense of us by focusing exclusively either on the uniqueness or the unity are doomed to failure. But we must not stop asking and questing because the answers are complex and ambiguous. We can do no better than to follow Linnaeus's advice, embodied in his description of *Homo sapiens* within his system. He described other species by the numbers of their fingers and toes, their size and their color. For us, in place of anatomy, he simply wrote the Socratic injunction: Know thyself.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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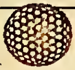
|  **Basket** A century later it has increased almost 650 times. | 30¢ | $200 |
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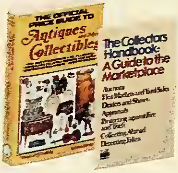
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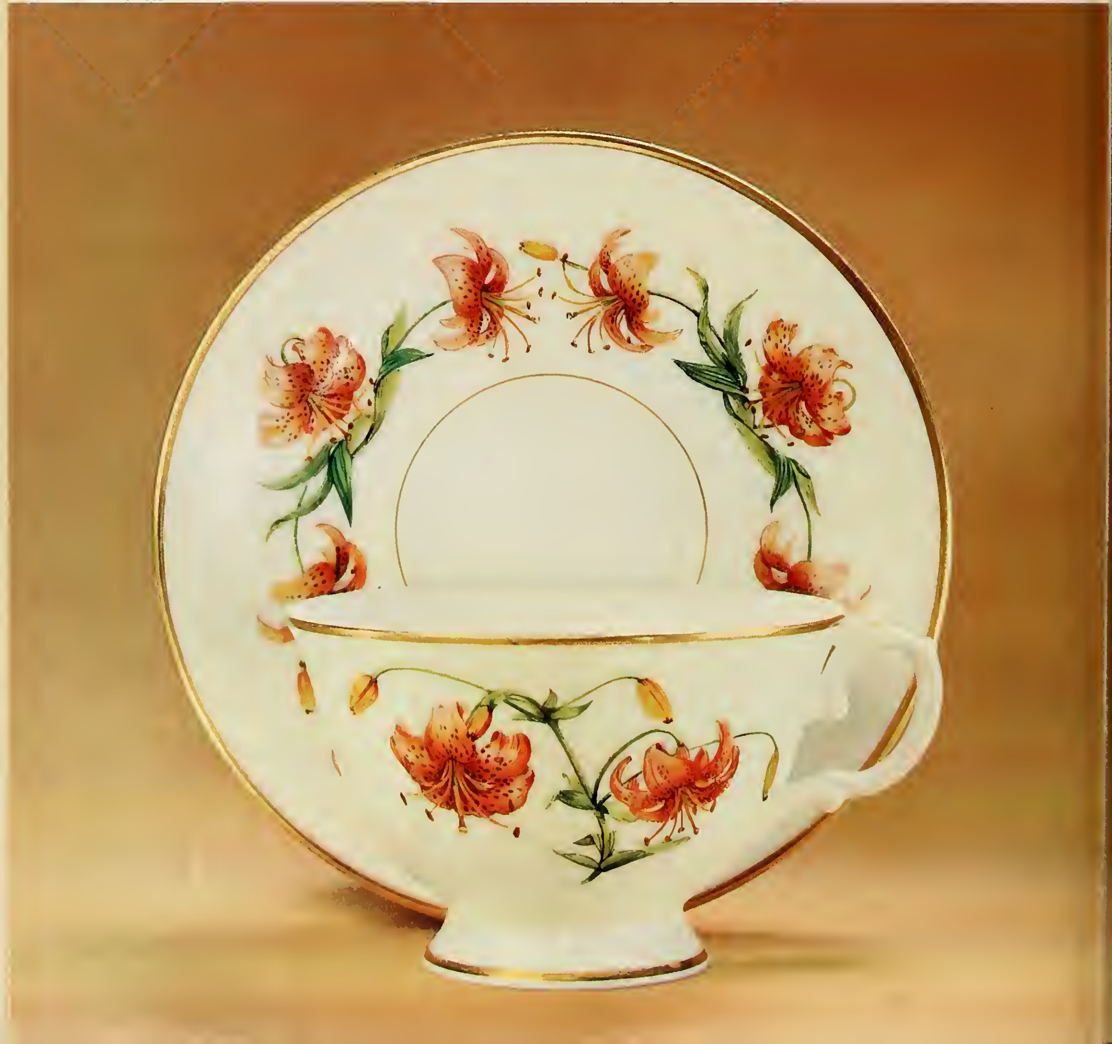

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# The Food Connection

*New crops and increased production allow populations to soar*

**by Peter Farb and George Armelagos**

The modern cultural adaptation that emerged first in Britain, then in Western Europe and North America, is now spreading rapidly around the globe—and even penetrating into the lands of remote pastoralists, horticulturists, and hunter-gatherers. Often regarded as synonymous with the Industrial Revolution—which began almost exactly two hundred years ago with James Watt's improved version of the steam engine—modernization entails much more than the replacement of human muscle by energy from machines. It involves developments in the structure of the family, the division of labor, the growth of population, and the environment, as well as diet.

The Industrial Revolution could not have taken place without the agricultural revolution that preceded it and that was based on an increase in production due both to new crops from the Americas and to new methods of farming. Yields of food were increased substantially by such simple techniques as the rotation of crops—a sequence from year to year, for example, of barley, clover, wheat, and turnips, instead of leaving the field fallow when its fertility had been depleted. The selective breeding of cattle also greatly increased the yields of meat and milk. In such ways, what had been an inefficient system of agriculture was eventually replaced by large-scale mechanized farming that took on the character of modern industry. Oliver Goldsmith in his poem *The Deserted Village*—published in 1770, five years before Watt's improved steam engine first came into use—described how the mechanization of agriculture had already forced many farmers to abandon their small holdings and migrate to the cities. This considerable portion of the British population provided the labor for an industrialization that would otherwise have been impossible.

One phenomenon of modernization has been an increasingly rapid rise in population. In 1750 the total population of the world was probably about 750 million, by 1830 it had increased to a billion, by 1930 it was two billion, and by 1975 four billion. In other words, the human species needed millions of years to reach a population of a billion, but thereafter the second billion was added in only a hundred years, the third in thirty years, and the fourth in a mere fifteen years. This growth was long attributed to a drop in the death rate that stemmed from advances in medicine, but some demographers now question whether medicine had much of an effect. Tuberculosis, for example, was the largest single cause of death in Britain in the last century, yet in the fifty years previous to 1882—when the tubercle baccillus was first identified by Robert Koch—deaths caused by it had already declined by about half. Pneumonia, influenza, infectious bronchitis, and other diseases also be-

Material adapted from *Consuming Passions: The Anthropology of Eating*, published by Houghton Mifflin © 1980 by the Estate of Peter Farb.

gan significant declines early in the nineteenth century, years before immunization and potent new drugs could have had any effect.

If not medical advances, then what can explain the change in the response to infection by people living in modern societies? The answer seems to be the profound effect of improved nutrition on the body's response to microorganisms. The decline in the death rate that occurred in Europe and in North America during the last century is being witnessed today in developing nations, and has the same probable cause. Well-nourished people have a much lower rate of infection and, even if infected, are much more likely to recover as compared to poorly nourished people. Before the widespread use of the measles vaccine, practically every child in every country caught measles, but three hundred times more deaths occurred in the poorer countries than in the richer ones. The reason was not that the virus was somehow more potent in poor countries or that these lacked medical services, but that in poorly nourished countries the virus attacked children who, because of chronic malnutrition, were less able to resist it.

Along with an improved agriculture came the introduction into Europe of new crops from the Americas, notably white potatoes into northern Europe and maize into southern Europe. In both Spain and Italy, where the cultivation of maize was widespread, populations soared—nearly doubling in Spain and increasing from eleven to

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eighteen million in Italy between the beginning and the end of the eighteenth century. The potato was not accepted so readily in Europe, even though it had been cultivated in the Andean highlands of Peru for about 2,500 years. It was at first regarded with suspicion, in part because it was grown from a tuber rather than from seeds, as were all other edible plants in Europe up to that time. But by the beginning of the eighteenth century, the potato had become a common food for peasants, who found in it the perfect crop for small parcels of arable land. Just one acre planted to potatoes could feed a family of five or six, plus a cow or pig, for most of a year. The plant could grow in a wide variety of soils, and it required no tools other than a spade and a hoe. It matured within three or four months, as compared to the well over half a year required for grain crops, and it had the advantage of a high nutritional value.

The most dramatic effect of the potato's introduction into Europe was seen in Ireland. By the middle of the eighteenth century, most of the Irish population was subsisting almost exclusively on potatoes, and Ireland's perennially recurring famines appeared at last to be ended. Potatoes do not have aphrodisiac powers, as was once believed, but they did contribute to the sudden increase in the Irish population, making large families possible because they provided a maximum of sustenance with a minimum of labor. The population of Ireland grew from just above three million in 1754 to more than eight million in 1845. Then a blight struck, bringing about the Great Potato Famine that was to last four years.

An increase in population as a result of new foods rather than of industrialization and medical advances also took place in China. The sweet potato, long grown by South American Indians, was early imported as a crop into China and was established by 1594, when it provided sustenance at a time when the native grains were succumbing to drought. An eighteenth-century agricultural commentary extolled sweet potatoes as a versatile crop that could be boiled, ground, or fermented; could be fed to animals, as well as to humans; and could grow in sandy, mountainous, and salty soils where grains did not survive. By that century, other New World crops were being widely grown: maize was allowing people from the crowded Yangtze region to migrate inland and farm drier lands; the white potato made it possible to bring into production lands that were too impoverished even for growing maize; and peanuts could be grown in the previously useless soils along rivers and streams. The new crops allowed a Chinese population that had reached the limits of its previous resources to begin a new spurt in growth. The numbers expanded from about 150 million people in the early 1700s to about 450 million only a century and a half later. The worldwide growth in population over the past several centuries is similar to what occurred in China, and can be assumed to have occurred for similar reasons. As soon as food resources could be moved from continent to continent because of the invention of long-distance transportation, a surge in population took place, one that had little to do with industrialization, shorter work hours, or advances in the practice of medicine.

People in modern societies usually assume that their own kind of mechanized agriculture is the most efficient known. But if the question is asked whether mechanized producers are really extracting from the soil a greater number of calories of food in proportion to the calories of energy they expend, the answer is no. In fact, they are very inefficient in this regard when compared with other adaptations—as is shown by a simple equation developed by anthropologist Marvin Harris that makes it possible to analyze the efficiency of any system for providing food energy:

$$\frac{E}{m \times t \times r} = e$$

That is, a society's annual production of food energy, *E* (as expressed in thousands of calories, or kilocalories), divided by the number of food producers (*m*), times the hours each works at food production during the year (*t*), times the calories expended per producer each hour in doing the work (*r*) equals *e*, that society's techno-environmental efficiency (in other words, the calories produced for each calorie of energy expended). Obviously, *e* must be greater than one because no society can survive for very long unless it produces more energy than it expends; actually, the value of *e* must be substantially higher than one to provide for such nonproducing activities as toolmaking, ceremonials, and recreation, among other things, and also to support the young, the elderly, the sick, and other nonproducers in the society. The larger *e* becomes, therefore, the greater is the society's techno-environmental efficiency in producing food energy above the amount it expends.

In a hunting-gathering society, such as the San, or Bushmen, of the Kalahari Desert, the equation is applied by Marvin Harris (using data collected by Richard Lee) as follows: A camp of twenty adults ($m$), each working 805 hours a year ($t$) and expending 150 calories per hour ($r$), to produce 23,000,000 kilocalories annually ($E$), has an efficiency of 9.5 ($e$)—which means that the San are producing between nine and ten calories for each calorie of energy expended.

This low efficiency does not allow much of a margin of safety and is insufficient to provide food for full-time specialists such as woodcarvers or priests. But the San cannot increase their efficiency because the average expenditure per producer of 150 calories an hour cannot be raised substantially; the human body simply cannot withstand long periods of being overheated or out of breath (which is why the average value for $r$ of 150 remains the same in all of the adaptations to be discussed here). For each adult in the camp to work more than 805 hours a year (an average of a mere two hours or so a day) would not solve the problem because the San can neither transport nor store a surplus, and any increased effort would quickly deplete the food resources around the camp. They might try to enlarge the population of their camp to increase the number of producers, but the food supply in the Kalahari Desert is insufficient to support dense populations that lack the knowledge and tools to build irrigation dams. So long as the San follow their traditional ways, they obviously can do almost nothing to increase their techno-environmental efficiency.

Nor would it be possible for the San to switch to horticulture, given both the harsh environment and their limited technology for overcoming it. Even if they could, Marvin Harris has shown, using energy data from a horticultural village in Gambia, West Africa, how little would be gained. Instead of the 20 food producers in the San camp, this Gambian village had 334, as well as a better climate for plant growth and a more complex technology. Yet the application of the equation shows an efficiency only slightly above that of the San. For an annual production of 460,000,000 kilocalories, 334 persons, each working 820 hours annually and expending 150 calories an hour, produce a little over 11 calories for each calorie of expended energy.

The main advantage of horticulture over hunting-gathering is not its much greater efficiency but rather that people can live together in larger and more permanent settlements. The denser population of a sedentary village allows for protection against enemies and gives greater opportunity for cultural interaction.

Detailed energy data do not exist for pastoral peoples, but their efficiency is believed to be no greater than for hunter-gatherers and horticulturists. It may indeed be less, since to allow domesticated animals to eat plant foods and then to eat the animal or its milk and blood takes the process of production through an extra step, with a loss of calories along the way. This assumption seems supported by the few studies that have been made. For one tribe of southern Tunisia that herds sheep and goats and also practices a little horticulture, anthropologist William Bedoian has calculated a techno-environmental efficiency of about six; for some Indians in the Andes of South America who are almost exclusively pastoralists, R. Brooke Thomas has determined the figure to be a little more than two.

Figures on efficiency under other adaptations do not increase by much until the complex level of irrigation agriculture is reached. This adaptation can feed more people on less land than any other, including mechanized agriculture. Over the millenniums, it has developed most notably in eastern Asia because of particular conditions prevailing there: many people to provide the labor for building and maintaining irrigation works, abundant water, and a shortage of arable land. As the irrigation system develops and production is intensified, more and more people are fed from the same amount of land—although at the price of increasing the amount of labor per unit of land, which means that the land must be worked ever more intensively by more people. Given this cycle, no one can become richer by working harder because the payments allocated to labor must be divided among a larger and larger force. And

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since such systems can develop only in the presence of an autocratic government, any economic growth that occurs is inevitably siphoned off by the bureaucratic elite that exists outside of the energy system.

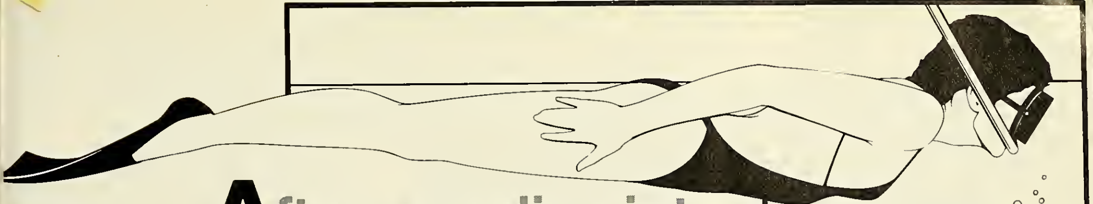
A detailed study of labor inputs and food yields for an irrigation village in Yunnan Province, China, before the fall of the Nationalist government shows a greatly increased techno-environmental efficiency over hunting-gathering, horticulture, and pastoralism. Four hundred eighteen persons, each working 1,129 hours annually, produced 3,788,000,000 kilocalories, resulting in between 53 and 54 calories produced for each calorie of energy expended. A higher efficiency, it should be noted, does not produce an increase in leisure, as is often supposed. Rather, each producer must work harder—in fact, some 35 percent more labor was performed by each of these Chinese than by each of the San.

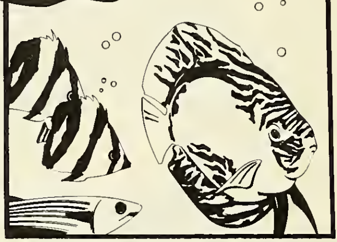
Of the nearly four billion kilocalories produced annually by this Chinese village, the villagers were estimated to need no more than a sixth of that amount. What happened, then, to the more than three billion kilocalories they produced each year over what they consumed? The surplus was used to feed the scores of millions in Chinese towns and cities who did not participate directly in food production, was sent to market and exchanged for manufactured goods, or was taken away in the form of taxes levied by the local, provincial, and national governments and in the form of rent payments to large landowners.

Modern societies are too complex to be analyzed by the equation employed here, but a few generalizations can be made. Once again, it is a mistake to suppose that modern societies allow people to work less hard for their daily bread. Out of the 1,129 hours worked by one Chinese irrigation farmer in a year, only 122 were needed to grow enough food to sustain that farmer. A blue-collar worker in the United States, on the other hand, spends 180 hours earning enough money to purchase a year's supply of food. Notwithstanding Western notions of the Chinese peasants' incessant labor, it is plain that they actually need to work less by a third than North Americans or Europeans to keep themselves supplied with food. Moreover, although a mechanized farmer in the American Midwest need put in an annual total of only nine hours of work for each acre to achieve an astounding 6,000 calories for each calorie of effort, that figure ignores the enormous amounts of human labor that go into manufacturing and transporting the trucks, tractors, combines, fuel, fertilizer, pesticides, fence wire, and everything else used by the farmer, not to mention transporting the food itself. For every person who actually works on a Midwestern farm, the labor of at least two others off the farm is needed to supply equipment and services directly to the farmer—aside from the very many more whose labors contribute indirectly to the final product. Altogether, a total of 2,790 calories of energy must be expended to produce and deliver to a consumer in the United States just one can of corn providing a total of 270 calories. The production of meat entails an even greater deficit: an expenditure of 22,000 calories is needed to produce the somewhat less than four ounces of beefsteak that also provides 270 calories.

In short, present-day agriculture is much less efficient than traditional irrigation methods that have been used by Asians, among others, in this century and by Mayas, Mesopotamians, Egyptians, and Chinese in antiquity. The primary advantage of mechanized agriculture is that it requires the participation of fewer farmers, but for that, the price paid in machines, fossil fuels, and other expenditures of energy is enormous. A severe price is also paid in human labor. Once the expensive machines have been manufactured and deployed on the farms, they are economically efficient only if operated throughout the daylight hours, and indeed farmers in the United States often labor for sixteen hours a day. The boast of industrialized societies that they have decreased the workload is valid only in comparison with the exploitation of labor that existed in the early decades of the Industrial Revolution. If the prevailing forty-hour work week of North America and Europe were proposed to the San, whoever did so would be considered to be exploitive, inhuman, or plain mad.

*Peter Farb, recently deceased, was an anthropologist and the author of* Man's Rise to Civilization *and* Humankind. *George Armelagos is a professor of anthropology at the University of Massachusetts.*





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# Acrobatic Pygmy Chimpanzees

*The behavior of this smallest of the great apes may help in interpreting the fossil record of human evolution*

**by Randall Susman**

**photographs by Noel Badrian**

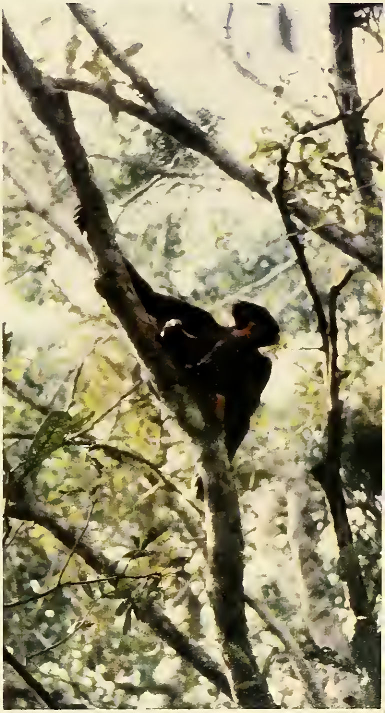
Lofinda, one of our guides, whispered softly and motioned toward the high canopy of the trees. I tried to find the pygmy chimpanzee but saw only a mosaic of green leaves, broken by beams of bright sunlight. With his finger frozen on the point where the animal was, Lofinda turned to me and again whispered, "Edja." Frustrated, I moved close to him, put my chin on his shoulder, sighted along his extended arm to the tip of his index finger, and finally spotted a dark silhouette perched on the end of a bough some eighty feet from the ground. At that moment the animal detected us, and as I focused my binoculars, he quickly moved closer to the center of the tree. There he grabbed another branch with one hand and swung along it to the trunk where he hesitated and looked down toward us. He was a magnificent animal, with a lustrous black coat. His pink lips contrasted with the coal black skin of his face, his nose was strikingly gorillalike, and his brow was an unbroken, heavy shelf across his forehead. The black hair on his face formed sideburns; the hair on his head was parted at the midline. He seemed to stare momentarily into my binoculars; then he scrambled to the trunk of the tree, paused, and slid down, fireman style, for thirty or forty feet. With a crash he dropped the last six or so feet to the ground and was off into the forest.

Weary, but exhilarated by my first contact with a wild pygmy chimpanzee, I sat down to rest. It had been three hours since our party had left camp to search for pygmy chimpanzees. We had arrived at our study site earlier that morning following a fourteen-day journey from Kinshasa, the capital of Zaire. After seven years of studying apes in the laboratory, I was thrilled to see these animals under natural conditions. Four years earlier, my colleague Noel Badrian and his wife, Alison, had conducted a six-month study of the pygmy chimpanzee *(Pan paniscus)* in this area. The first primatologists to observe pygmy chimpanzees in the wild, they had gathered some ninety hours of observations on social behavior, feeding, and other aspects of pygmy chimpanzee ecology. Unfortunately, their study was cut short for lack of funds. I returned to the Lomako Forest with Noel to gather data on locomotor behavior and add to the Badrians' earlier work. Noel, Alison, and I hoped that our studies would prove that careful observations of pygmy chimpanzee behavior could be carried out in the field and that our efforts would develop into a long-term project on the behavior and ecology of pygmy chimpanzees.

These animals, which we had come so far to observe, first captured the attention of anthropologists some fifty years ago, when the study of great ape behavior began to come into its

*Perched high in the canopy, a robust adult male pygmy chimpanzee is unaware that he is being observed. The name "pygmy" is clearly a misnomer since large males often weigh more than 100 pounds.*

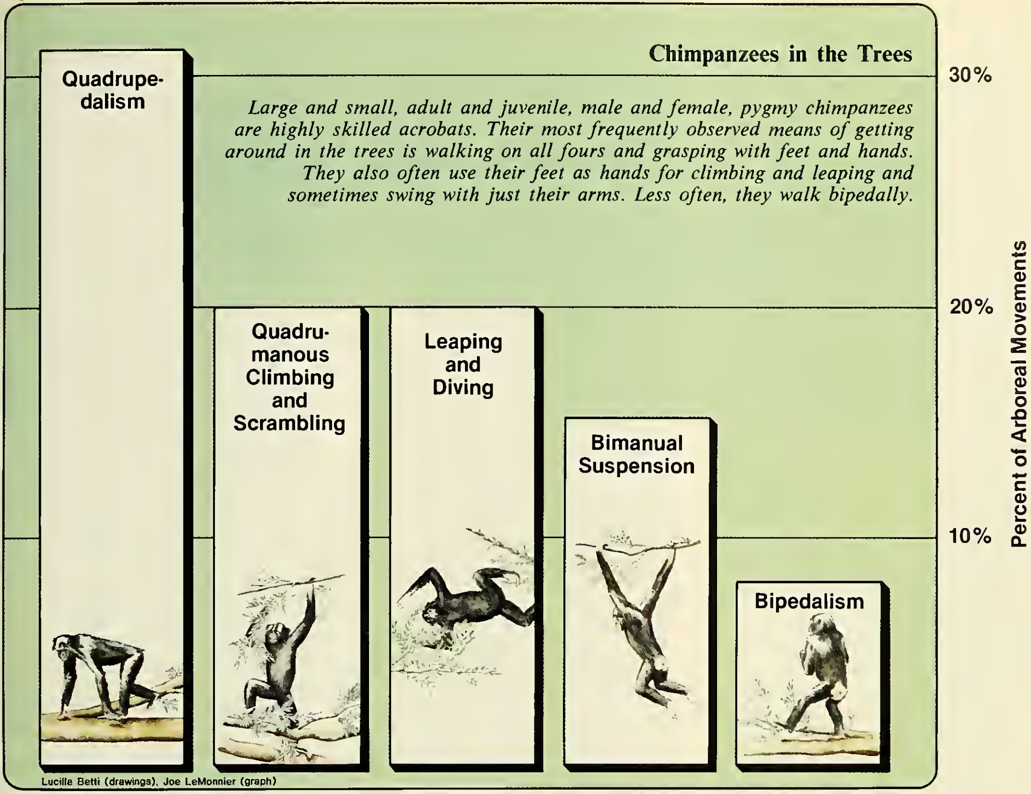
*From its vantage point high in a tree, a young male pygmy chimpanzee looks down at the photographer. Such males will often approach an observer, attracting attention to themselves while other chimpanzees in the group slip away.*



own. Although captive pygmy chimpanzees were observed in the mid-1920s by Robert Yerkes and others, the animal was not recognized as a distinct species until Ernst Schwarz's work in 1929. Harold Coolidge published the first detailed paper on the biology of the pygmy chimpanzee in 1933. Using museum records of localities from which specimens were collected, Coolidge mapped out the range of the pygmy chimpanzee, as he called the animal. He noted that the pygmy chimpanzee was found on the left bank of the Zaire (formerly Congo) River, while the common chimpanzee occurred on the right bank to the north. Coolidge further reported the eastern extent of the range as the Lomami River, and roughly defined the southern boundary by a line connecting Lukolela in the west and Mondombe in the east. Although a number of different distribution maps for the pygmy chimpanzee have been published since Coolidge's, information collected during the past few years shows that his map provides the most accurate assessment of the species' range.

From the start, anthropologists and primatologists were intrigued by descriptions of a dwarf, or pygmy, chimpanzee. (No one now believes that the creature is a true pygmy version of the common chimpanzee, but the name is still in popular usage.) The Dutch anatomist Louis Bolk had published his "fetalization theory" of human evolution in 1925, and Raymond Dart had almost simultaneously reported on the finding of an ancient, small, apelike hominid from South Africa—*Australopithecus africanus.* Bolk proposed that the human body form was the result of hormonally regulated "retardation" of growth processes. At maturity, humans have not moved as far from their juvenile or fetal stages as have adult apes. In fact, juvenile humans, monkeys, and apes are morphologically quite similar. Monkeys and apes, however, display accelerated adolescent growth

*Because of their small size, black mangabey monkeys can leap farther than can pygmy chimpanzees. The quieter chimpanzees are often found by locating the raucous monkeys with whom they frequently feed.*



**Chimpanzees in the Trees**

*Large and small, adult and juvenile, male and female, pygmy chimpanzees are highly skilled acrobats. Their most frequently observed means of getting around in the trees is walking on all fours and grasping with feet and hands. They also often use their feet as hands for climbing and leaping and sometimes swing with just their arms. Less often, they walk bipedally.*

Lucille Betti (drawings), Joe LeMonnier (graph)

that, among other things, results in adults that are morphologically more distinct from their younger counterparts than is the case with humans.

Schwarz observed that adult pygmy chimpanzees also appeared to retain "youthful characters" to a great extent, while maintaining a close similarity to common chimpanzees. To add to this, Dart's description of a fossil "humanoid" skull that revealed similarities with chimpanzees and gorillas sparked a longstanding controversy that would only be resolved when much more information on the morphology of extant apes and humans (and fossil evidence) became available.

Schwarz suggested that the pygmy chimpanzee might be an important element in the debate over whether *Australopithecus* represented a "dwarfed gorilla." Schwarz, Coolidge, and other workers placed the pygmy chimpanzee squarely in the context provided by Bolk and Dart. Anthropologists were immediately excited by all the implications relating to the very existence of a pygmy chimpanzee and many new thoughts and hypotheses quickly appeared. Few anatomical studies were actually conducted on the morphology of the animal, however, and no fieldwork was undertaken for the next thirty years. The remote, restricted range of the pygmy chimpanzee in the rain forest of Zaire no doubt accounted for the latter fact.

In recent years, discoveries of fossil apes and ancient humans have rekindled interest in the evolutionary biology of the pygmy chimpanzee. First, similarities in overall size and dental and facial proportions of *Ramapithecus* (possibly the earliest bona fide member of the hominid line) and the pygmy chimpanzee engaged the attention of primate paleontologists, who took a strong interest in the morphology and behavior of the pygmy chimpanzee. Second, new finds of two- to three-million-year-old hominids in eastern Africa, as well as those found earlier in South Africa, revealed size differentials in early humans that recalled the differences between the pygmy chimpanzee and the common chimpanzee. Most important, however, was the lingering notion that the pygmy chimpanzee, smallest of the great apes, was less specialized adaptively than chimpanzees, gorillas, or orangutans, and that for this reason it might provide the best living analogy with the behavioral patterns of our earliest apelike human ancestor.

As Coolidge had stated some thirty years earlier, less specialized meant, to most people, that an animal more closely resembled an ancestral state than did a more specialized form. Coolidge further noted that "the paniscus, a true paedomorphic species which shows definitely juvenile characteristics in an adult state, is the most important of the chimpanzees in a study of the phylogeny and relationships of this higher order of anthropoid apes. It may approach more closely to the common ancestry of chimpanzees and man than does any living chimpanzee. . . ." Specifically, the questions that were formulated in the late 1960s were (1) What is the place of the pygmy chimpanzee in the phylogeny of the African apes and humans? and (2) How can investigations incorporating behavioral and anatomical data on *Pan paniscus* aid in reconstructing the behavior of early human ancestors?

In the early 1970s extensive studies of the teeth and skulls of pygmy chimpanzees and preliminary investigations of their skeletons were carried out. Attempts to collect data on the behavior of free-ranging pygmy chimpanzees were also made and more formal studies of captive behavior were begun. From the information that was gathered, two poles of opinion emerged on the question of the phylogenetic affinities of the pygmy chimpanzee and its place in the family tree of African apes and humans.

Some scientists suggest that the pygmy chimpanzee closely represents the prototype from which humans and the African great apes have evolved. They suggest that the pygmy chimpanzee's smaller size and relatively small cranial, facial, and dental dimensions make it a better model of the prehominid ancestor than either the common chimpanzee or the gorilla. To underscore such similarities to humans these scientists further suggest—largely from observations of captive animals—that pygmy chimpanzees walk bipedally more often than common chimpanzees do and engage in more complex and variable sexual and copulatory interactions than other chimpanzees. Proponents of this school also emphasize the size similarities of early hominids and pygmy chimpanzees and the "generalized" hominoid morphology of the latter.

Other scientists, however, have pointed out that the similarities of the pygmy chimpanzee and early hominids such as *Australopithecus* or *Ramapithecus* are revealed only in a certain few morphological traits, many of which can be attributed to the overall effect of small size. In other words, these similarities in size may mask many important underlying adaptive differences. These workers feel that pygmy and common chimpanzees are equally good working models for the common ancestor of humans and African apes, and that acceptance of the pygmy chimpanzee as *the* prototype is not warranted by our limited knowledge of the species. Nevertheless, both schools agree that the pygmy chimpanzee is a highly significant, still untapped reservoir of information for interpreting the fossil record of human evolution.

The desire to make functional or behavioral inferences about the fossil record sparked my own interest in *Pan paniscus.* When similarities and differences are found between living forms, anatomists attempt to link these to similarities and differences in their behavior. In this way an explanation—or the "why"—of morphology is developed. Such observations can be applied to fossils (if the fossils are similar enough to the corresponding bones of living animals), and we can then postulate or reconstruct the behavior of extinct species. On a practical level this is difficult. Often the best we can do is suggest how a particular part of the body may have functioned—for example, the knee or the hip. But such analysis and inference often prove significant because an individual bone may be the key to understanding whether an animal habitually walked upright or on all fours; whether it climbed trees or lived primarily on the ground.

Earlier studies of pygmy chimpanzee morphology, including one of my own, have revealed subtle but distinct differences between pygmy and common chimpanzees, many of which are independent of simple size differences. These include the length of the shoulder blade, the shape of the finger bones, and the long lengths of the upper and lower limbs in the pygmy chimpanzee relative to its body weight. Statistical analyses suggest that there are significant differences among pygmy and common chimpanzees and other apes that are revealed in the hand and shoulder. These differences seem to correspond to the relative amounts of suspensory activities (hanging, climbing, and arm swinging) that occur in each species.

The data on pygmy chimpanzees were interesting and suggested, among other things, that pygmy chimpanzees are more arboreal than common chimpanzees. But we were at a loss to confirm this interpretation of our anatomical observations. Noel and I designed a brief field study to try to determine how pygmy chimpanzees moved about in their native habitat so that we could verify or deny the hypotheses developed in the labora-

*These pygmy chimpanzees, a male (right) and a female, groomed each other for an hour, alternating as groomer and groomed every few minutes. Chimpanzees often engage in this activity after feeding.*

tory about pygmy chimpanzee locomotion. We intended to eventually combine the behavioral and morphological observations and hoped the combination would help us infer the locomotor characteristics of selected fossil apes and humans, and especially, shed light on the critical question of how hominid bipedalism originally evolved.

The initial observations that Lofinda and I made were only the first of many sightings that our party made during the next four weeks. We logged nearly twelve hours of detailed observations on locomotion and feeding alone—more than anyone had previously collected. Most of the time we encountered small groups of five to eight animals feeding high in the crowns of fruit trees. Groups consisted of a large male (weighing 100 pounds or more), one or two smaller males, and two or three females—one or two of which might be carrying an infant. When we approached, the group members frequently spotted or heard us. Sometimes they continued to feed; at other times they hurriedly descended the trees and fled on the ground. In both situations a male would interpose himself between us and the group, attracting our attention with a noisy, bough-drumming, bipedal display (standing on his hind limbs, waving his arms, and vocalizing) or just moving toward us to build a nest or feed. Often, while the prominent male had our attention, the rest of the group would quietly move off. This behavior of the males recalled the sentry and display behavior of patas monkey males.

Patas monkeys live on African savannas and are notable for their behavior when threatened with danger. The males make noise and motions to attract attention while the females and the young slip off quietly. The males then run off at high speed in another direction. Neither gorillas nor common chimpanzees show such organized deception.

From footprints, plant remains, and direct observations made by Lofinda and his son Ikwa, we learned that pygmy chimpanzees spend a large part of the day on the ground. Much of their diet consists of fruit, but pygmy chimpanzees regularly eat a number of canes and herbs that are found on the forest floor. In addition, Noel and Alison had earlier observed and reported insect and small mammal remains in pygmy chimpanzee feces.

Pygmy chimpanzees are basically quadrupedal knuckle walkers when on the ground, but they engage in other mixes of walking as well. Ikwa observed a large male pygmy chimpanzee walking bipedally on the ground. When he spotted the guide, the startled animal dropped the canes he was carrying, stomped, defecated, and then turned and fled on all fours.

In the trees, pygmy chimpanzees are highly skilled acrobats, and adults are reported to be more agile and daring than adult common chimpanzees. Large and small animals of both sexes, as well as pygmy chimpanzee mothers with infants, arm swing, leap, and dive in the high canopy. Juveniles engage in acrobatic play and are also adept arboreal bipeds. We observed several instances of bipedal walking along large boughs at heights of 100 feet and more, usually when animals were carrying objects or when they engaged us with behavioral displays. The relative frequency of bipedal locomotion—it occurred in 10 percent of our observations—was comparable to that reported for gibbons by C.R. Carpenter and later workers. In one instance, Noel observed an adult male at the end of a long bough. He displayed at Noel and Ikwa, then apparently not quite finished feeding, he walked bipedally for a distance of fifteen feet or so carrying bunches of fruits in each hand.

We were able to render our findings in a quantitative way so that they could eventually be compared with similar observations on common chimpanzees and other apes. We kept a record of the number of times we observed pygmy chimpanzees in motion in the trees (arboreal locomotor bouts) and of what kinds of behavior were observed in each instance. The most frequent behavior was walking along a bough on all fours, grasping with feet and hands. This behavior occurred in more than 20 percent of the observations (a total of 41 times). Other common behaviors were scrambling along any part of the tree, using all fours (seen in about 20 percent of the observations), and leaping or diving from a bough (also seen in about 20 percent of the observations). Swinging from a bough with both arms occurred in more than 15 percent of the observations. Other behaviors were less common.

Comparisons of pygmy and common chimpanzees, even on the basis of the limited data we have at present, are provocative. Descriptions of chimpanzee locomotion by a number of researchers, including Jane Goodall, Vernon and Frances Reynolds, and Adrian Kortlandt, indicate that adult chimpanzees (which are heavier than pygmy chimpanzees by 10 to 15 percent) are cautious climbers and arm swingers in the trees. Although young common chimpanzees actively chase and play in the trees, adults engage in dynamic displays mainly when they are excited. Like pygmy chimpanzees, common chimpanzees travel from one feeding spot to another on the ground, but when in the trees, and this is a critical qualifier, pygmy chimpanzees appear to be far more acrobatic.

Our conclusion that pygmy chimpanzees are better than common chimpanzees at leaping, diving, arm swinging, and walking upright in trees rests on our quantitative assessment of the frequency and context of the various modes of pygmy chimpanzee locomotion. And it confirms our initial studies of pygmy chimpanzee and common chimpanzee anatomy, in particular the structure of the shoulder blade, arm, and hand, which suggest that the pygmy chimpanzee is more arboreal than its relative. But these are not definitive conclusions, and our studies are continuing. We need more anatomical and field studies of both animals to nail down the differences we believe we see.

If our findings are confirmed, we will have a series of living apes, closely related to, but differing in locomotor behavior from, the human lineage, that can be used to explain the morphology of fossil apes and humans. As to how good a model the pygmy chimpanzee is for the common ancestor of humans and apes, I believe that it cannot be taken as the best model to the exclusion of the common chimpanzee.

Although the pygmy chimpanzee appears at first glance to be the ideal candidate for modeling the ancestral human condition, close inspection of selected elements of pygmy chimpanzee anatomy and recent discoveries of early human fossils cast doubt on how ideal it is. Recent fossil evidence, from various sites in Africa (Hadar in Ethiopia, and Laetoli in Tanzania), of hominids as old as 3.75 million years indicates that early human ancestors showed a much greater anatomical difference between the sexes than do pygmy chimpanzees. The common chimpanzee, other apes, and modern humans all exhibit greater differences between the sexes in body shape and size than do pygmy chimpanzees. Thus, it may be that the similarity of the sexes in the pygmy chimpanzee is not an indication of its similarity to a generalized primate ancestor but a more recent adaptation.

Problems always arise in trying to read back from a living creature to an extinct one. An animal that lives today may have changed less than some other animal in terms of a common ancestor, but all have changed. And some aspects of each species have changed more than others. Chimpanzees or pygmy chimpanzees may be closer than human beings are to our common ancestor—that is, they may have changed less since divergence. But some aspects of the apes are recent and highly specialized adaptations. For example, both chimpanzees (pygmy and common) and gorillas engage in knuckle walking, an adaptation to a mixed life in the trees and on the ground that allows the apes to have long grasping fingers and still walk comfortably on all fours. No other apes exhibit this behavior, and there is no evidence of it occurring in any of the fossil primates we know.

To begin to do what we want to do—read into the fossil record behavioral interpretations bolstered by evidence gained from our investigations (behavioral and anatomical) of living apes—we need to learn more about the anatomy of humans and of apes other than the pygmy chimpanzee, and to avoid the pitfalls of comparisons. We have to determine which traits are conservative (common to all apes and humans) and which are derived (peculiar to a subgroup of apes, African apes, for instance, and humans).

Such distinctions are absolutely necessary in reaching conclusions about the special affinities of humans with any one ape species. And such distinctions are also a necessary prelude to using living apes to deduce the behavior of our fossil ancestors. ☐

*Pygmy chimpanzees sometimes walk bipedally in the trees, usually when carrying objects or displaying. This adult male, on a horizontal bough eighty feet high, is holding fruit from the boongola tree in each hand.*

# In Search of Ancient Pack Rats

*The discovery of fossil pack rat middens has uncovered a 30,000-year-old environmental record*

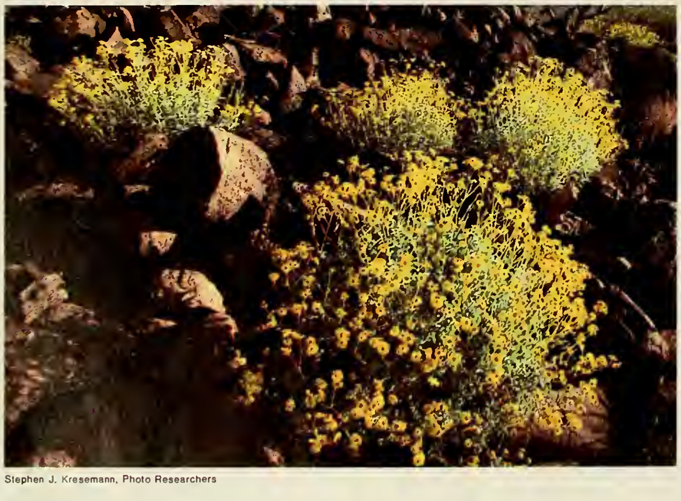
**by Jim I. Mead**

On a very hot day in March, a field party from the Univeristy of Arizona set out to survey the lower part of the Grand Canyon for late Pleistocene fossil sites. Spring was already in full swing at the lower elevations Brittlebush blanketed the talus slopes with orange-yellow bouquets and the rich purple flowers of beavertail prickly pear cactus dotted the rocky landscape. I headed off alone up an unnamed canyon. My plan was to systematically examine the limestone cliffs of the Mauv Formation in search of fossils that would provide a record of life in the Grand Canyon during the last Ice Age. By midafternoon I had located evidence that promised to answer many questions about the Grand Canyon's past.

The last great advance of the continental ice sheets that covered all of Canada and part of the northern United States occurred approximately 22,000 to 14,000 years ago. This period is technically known as the Late Wisconsin Glacial, or more commonly, the last Ice Age. About 14,000 years ago the ice sheets began an oscillatory retreat. As these dominating masses shrank from the scoured and denuded land, plants and animals all over North America altered their existing ranges in response to the new environmental conditions. For thousands of years, environments had remained relatively stable because of the presence of the huge ice fields. But with the warming trend of the late glacial periods, plants and animals had to adapt. The hope of our party was to discover fossil deposits that would help piece together the fate of Ice Age plant and animal communities that are no longer found within the Grand Canyon.

I was searching for the cemented organic residues of pack rat dwellings. There are at present eight species of this medium-sized rodent in the United States. All pack rats have a habit of collecting seeds, leaves, flowers, twigs, bones, and other small objects from within their 300-foot foraging range. Forming an excellent sample of the local biotic community, these items are used for food and for constructing the dwelling in which the pack rat lives. Periodic cleaning by the pack rat produces a pile, or midden, of discarded material. Repeated trampling and urination compact the midden into a hard, cemented waste accumulation. When the wastes are deposited on a more or less horizontal surface, the deposit can be as evenly bedded as a layer cake. If it is located in a protected and dry rock crevice or cave, the midden will be preserved as long as the shelter exists.

Most of the morning was spent pok-



Stephen J. Kresemann, Photo Researchers

*Herbaceous and thorny desert plants such as brittlebush, left, have been common at lower elevations of the Grand Canyon for about 7,000 years. The desert pack rat, right, can tolerate the canyon's hot, dry summers and cool winters.*

Tom McHugh, Photo Researc

ing my head in and among the numerous shelters and rock crevices of the cliff. Occasionally, a large vertical crack would require me to chimney-up the crevice to make absolutely sure that there were no hidden cave entrances or fossils. While hiking along a narrow talus slope 500 feet above the canyon bottom, I spotted the horns of a bighorn sheep barely showing above a dense bush some twenty feet away. Had I surprised this wary canyon dweller? Bighorn sheep are known to live in many regions of the Grand Canyon. Their trails are common in areas I have surveyed. As I crept up to the protruding horns, I found that what used to be a magnificent ram was now a mummified, curled-up carcass. I had no way of knowing how long the sheep had been dead, but because of the Grand Canyon's arid climate, organic remains in a crevice or cave, beyond the drip-line of seasonal rainstorms, will be preserved almost indefinitely.

By noon I had surveyed a fair distance up the canyon. During lunch I saw what appeared to be a small hole at the cliff base of a side canyon. Was it really a cave entrance or just another tempting shadow? Something told me to check it out, if nothing else, just to be consistent about my survey. The ever present echoing call of a canyon wren kept me company as I made my way into the steep-walled side canyon. The two turkey vultures that I had seen early in the morning were now flying directly above me; the sight almost made me wonder what I was getting myself into.

Peering with my flashlight between the fallen limestone blocks, I could see that this was no mere boulder pile, but a cave entrance. I wormed in a little farther to get a better view, my eyes straining to adjust to the darkness. Then I caught it—the overpowering, pungent, yet somewhat sweet smell of fossil rodent urine—pack rats! I never thought that such a musty odor would get me so excited. I quickly squirmed into the cave and peered around the small room. Pack rat middens were lying all about the room. But how old were these middens? Pack rat middens that are still being formed are common throughout the Grand Canyon. With my chisel and geologist's hammer, I broke off a chunk of a rock-hard midden and closely examined the protruding contents. There were hundreds of seeds and twigs of juniper and singleleaf ash. Feather fragments and bones of the California condor, along with a camel tooth, were indicative of a biotic community long since gone from the area.

With permits from Grand Canyon National Park headquarters, I returned many times to study the middens in detail. The cave, now named Vulture Cave, was mapped to locate the middens and each was examined in cross section to determine individual stratigraphic complexities. Each individual layer was sampled and packaged for transport to the Laboratory of Paleoenvironmental Studies in Tucson.

In the lab, individual layers were placed in water to dissolve the cementing urine. After a few days, the urine-saturated water was poured through a fine strainer. Repeated washings disaggregated all the midden components, which were then oven dried. Handpicking segregated the fossils (bones, seeds, leaves, and a host of obscure items). The final task of identifying all the fossils was done by using plant and animal comparative collections located on the University of Arizona campus. Many of the fossils were so well preserved that they could be recognized as belonging to living spe-

Grant Hailman

*Lupines, desert poppies, and Mexican poppies (not true poppies) blossom in an arid field near the Grand Canyon. During the last Ice Age, a juniper woodland community probably covered the area.*

Jen & Des Bartlett; Bruce Coleman

*Turkey vultures moved into the Grand Canyon 6,000 to 7,000 years ago. Two of the birds circled over the author as he traversed a steep-walled canyon and led him to name the cave he discovered, Vulture Cave.*

cies. About five to ten grams of plant material were sampled from each midden layer and radiocarbon dated. This provided a precise age of when each midden layer and its fossils had been deposited in the cave. The analyses and radiocarbon dates of some twenty middens from Vulture Cave revealed a fascinating glimpse into the past.

The Grand Canyon's present plant and animal communities are a guide to understanding the changes that occurred during and since the Ice Age. Today, the area around Vulture Cave (2,120 feet above sea level) and most of the lower elevations of the western reaches of the canyon are dominated by herbaceous and thorny shrubs common to the Mohave Desert: creosote bush, brittlebush, sandpaper bush, cat's-claw acacia, and numerous cactus species. Animals that live in this plant community can tolerate the hot, dry summer months and the relatively cool winters. The desert and white-throated pack rat, bighorn sheep, desert tortoise, chuckwalla, collared lizard, desert spiny lizard, and side-blotched lizard are common. These desert species gradually drop out at higher elevations and are replaced by woodland forms at approximately 4,500 feet. Utah juniper, shadscale, Utah agave, and bear grass, to name a few, become the dominant plants. The Mexican and Stephen's pack rats are present, along with the western fence lizard, which is tolerant of the cool temperatures of the woodlands. The canyon rims at 6,000 feet are dominated by piñon-juniper woodlands. The bushy-tailed pack rat, mountain lion, mule deer, mountain kingsnake, Abert's squirrel, black bear, porcupine, and Merriam's shrew inhabit these cooler woodland and pine forest regions. Bighorn sheep are also present, but in fewer numbers than at the lower elevations of the canyon.

The fossil pack rat middens from Vulture Cave provide a detailed environmental record from 23,000 to 11,000 years ago. They indicate that prior to the last Ice Age maximum, the slopes around Vulture Cave supported a juniper–single-leaf ash woodland, along with certain characteristic desert species. The closest woodland today is some 2,800 feet higher and seven miles farther north. The animals from this early glacial period are not well known except for the desert tortoise, collared lizard, and the desert shrew, the same taxa that are present in the lower Grand Canyon today.

The full glacial period was a time of slight change in the Grand Canyon. The juniper woodland community, reaching the beaches of the Colorado River, contained blackbrush and shadscale as codominants, while single-leaf ash seems to have been more restricted. The animals living within that more or less xeric woodland included the marmot, which at present does not inhabit Arizona, and the Mexican, or longtail, vole, presumably the species that is now restricted to the canyon rim forests. The desert element was represented by the side-blotched lizard and sandpaper bush.

In the western Grand Canyon the last glacial period (approximately 18,000 to 10,000 years ago) saw a return to the early glacial community with single-leaf ash again codominating with juniper in the woodland. Late glacial age animals are well represented in Vulture Cave's midden fauna. The desert fauna included the desert tortoise and chuckwalla; woodland animals included the porcupine, marmot, and vole. Mule deer, bighorn sheep, pronghorn, and a now extinct camel browsed the vegetation near Vulture Cave, while the California condor soared through the canyons searching for large carcasses. And large carcasses there were. Besides the already mentioned large herbivores, a nearby fossil deposit, Rampart Cave, contains evidence that the extinct Shasta ground sloth and Harrington's mountain goat also roamed the lower Grand Canyon.

The same arid environment and the protective caves that preserved the pack rat middens also have mummified the dung of some of these extinct herbivores. Rampart Cave is one of seven caves in western North America that contain the dried dung of the Shasta ground sloth. Being made of organic material, fossil dung can be radiocarbon dated. Paul S. Martin dated numerous dung balls that he found on the surface of the Rampart Cave deposit (see "Sloth Droppings," *Natural History*, August–September 1975). He discovered that the sloth last voided in Rampart Cave 11,000 years ago. Richard M. Hansen of Colorado State University recently examined plant fragments from the Rampart Cave sloth dung. He found that the sloths browsed on globe mallow, Mormon tea, cat's-claw acacia, and mesquite. Analyses of pack rat middens from Vulture and Rampart caves indicate that globe mallow and Mormon tea were probably common constituents of the local community for at least 30,000 years. All plants eaten by the Shasta ground sloth still grow in the area of the cave today. Based upon its diet, the Shasta ground sloth could live in the Grand Canyon today. Martin believes that Paleoindians hunted the sloth to extinction 11,000 years ago.

Precisely when the Ice Age came to an end in the Grand Canyon is not certain. Based upon the Vulture Cave record and a few other nearby pack rat middens, some woodland plants and animals began to disappear from the lower elevations of the western canyons about 14,000 years ago. At this same time, desert species, most of which were already there, began to increase in abundance. Other pack rat middens located near Vulture Cave indicate that the last plant vestige of the Ice Age woodland was the juniper, which persisted near the cave until about 8,500 years ago. The end of the Ice Age was apparently not catastrophically abrupt, but more or less a gradual change or a series of minor, abrupt changes in the environment over a period of some two to four thousand years. The Vulture Cave record is largely absent for the period between 10,000 and 2,000 years ago. The middle Holocene, less than 7,000 years ago, was certainly a time of desert vegetation, as it is today. The woodland taxa typical of the glacial period had retreated to the higher portions of the Colorado Plateau bordering the Grand Canyon. A ring-tailed cat den and a pack rat midden, both located in Vulture Cave, preserved a detailed record

*The entrance room to Vulture Cave is located 2,120 feet above sea level. Fossilized pack rat middens were found lying all about the floor of the cave. Analysis of the urine-cemented middens revealed them to be up to 30,000 years old. Among the items identified in the middens were seeds and twigs of former woodlands, feathers and bones of the California condor, and a camel's tooth. The environmental history of the Grand Canyon is now more complete because of these finds.*

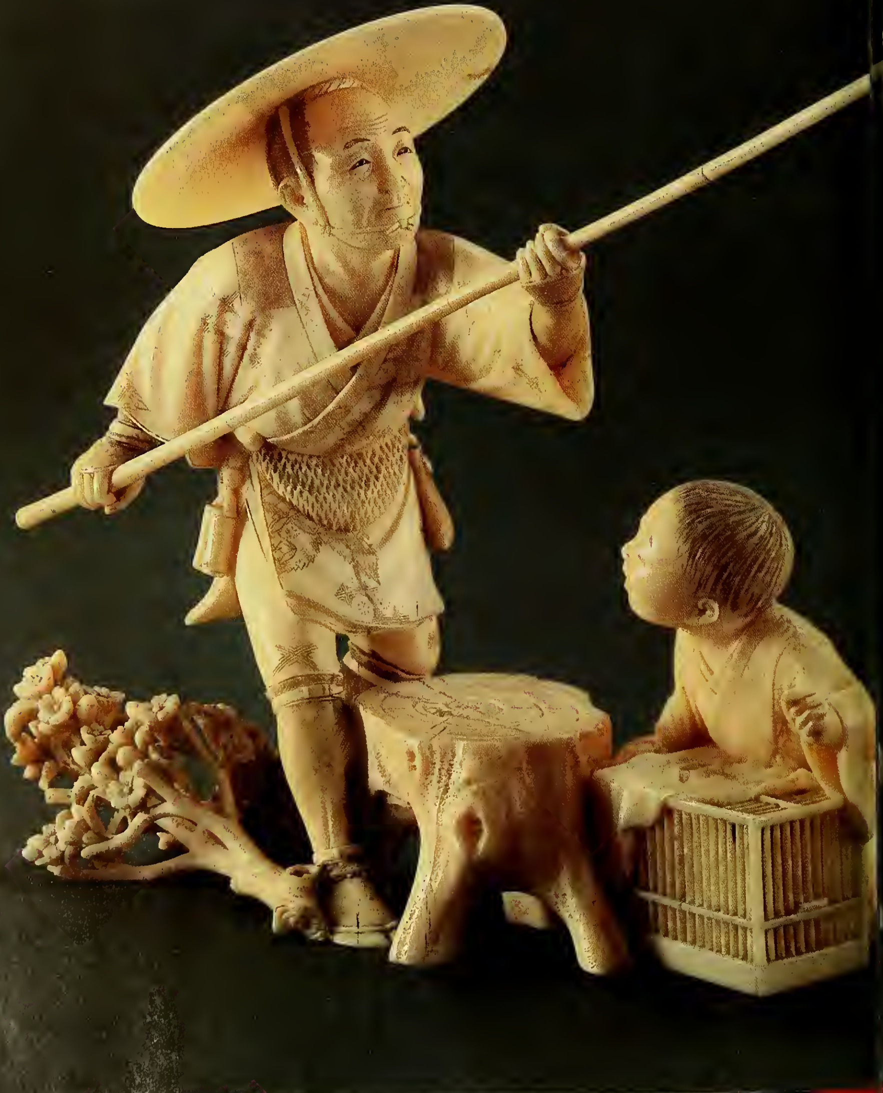
Arthur M. Phillips, III

Hans Wendler, fpg

of the local fauna and flora of the late Holocene. The local desert community contained at least eight species of lizards, including the banded gecko, chuckwalla, and the poisonous Gila monster. At least ten different snakes inhabited the local desert including the milk snake and rattlesnake. Turkey vultures had moved into the canyon.

That hot sunny day's hike in the Grand Canyon was a success. I had discovered a dry cave that had preserved a detailed record of the animals and plants that inhabited the western Grand Canyon reaching back in time 30,000 years. Since that inspiring find, I have traveled many times to the Grand Canyon. Each time while I stand on the rim overlooking the canyon, I try to visualize what it looked like when woodland reached clear down to the Colorado River and condors soared below the rim. On my last trip to the canyon, I watched a white-throated pack rat run from a cactus to its den, and wondered what treasures of the present biotic community it was packing away in its sheltered den to be preserved for some future paleoecologist. ☐

*A nineteenth-century Japanese okimono, or decorative ivory carving, from the American Museum's Drummond Collection*



# Impressions of Traditional Asia

*The anthropologist behind the Museum's newest and largest exhibition gazes upon half of humanity*

By Walter A. Fairservis, Jr.

Photographs by Lee Boltin

This material is adapted from a forthcoming book by Walter A. Fairservis, Jr.

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# Asia

## Mother of Civilization

Asia is the unrivaled continent of superlatives: it has the largest land area, the greatest number of people, the highest mountains, the first civilization, the first writing, the first alphabets, the earliest agriculture, the first cities, the first codified law, the oldest continuous monarchy, and the oldest ethical faiths in the world. Some would call Asia the Mother of Civilization.

A new, permanent Hall of Asian Peoples, opening in October at the American Museum of Natural History, was designed to display some of the material evidence for Asia's cultural priorities. At the same time, the hall will emphasize who the Asians are and promote better understanding of the traditional cultures of Asian peoples from Turkey to Japan, from the arctic rim of Siberia to Cape Comorin at the southern tip of the Indian subcontinent. These traditional cultures have been enormously attractive to the West from the days of Alexander the Great to the present-day tourist seeking old splendors under modern veneers.

The West has been drawn to Asia not only by its wealth, rich crafts, spices, and other material exotica, but also by its particular ways of viewing the world—most of them so different from Western beliefs that they raise many questions. For example, why do the Indians arrange society in castes? Why did traditional China emphasize the past as the model for the future, whereas ancient Judaism stressed the present as preparation for the future? Why does Zoroastrianism conceive of the world as a struggle between good and evil, insisting that fire, earth, and water be left unpolluted by man? Why do Tibetans have both polygamy and polyandry? What is ancestor worship and what are the five basic Confucian relationships?

No single museum hall can answer all these questions, but it can present an overall Asian self-view. The basic Asian view of life is the underlying focus of the hall. Within that fundamental theme, smaller motifs run from section to section. These are Asian ideologies, social organization, authority, economics, technologies, pertinent languages, and aesthetic styles. But before Asian outlooks can be appreciated, the geography of the continent must be understood.

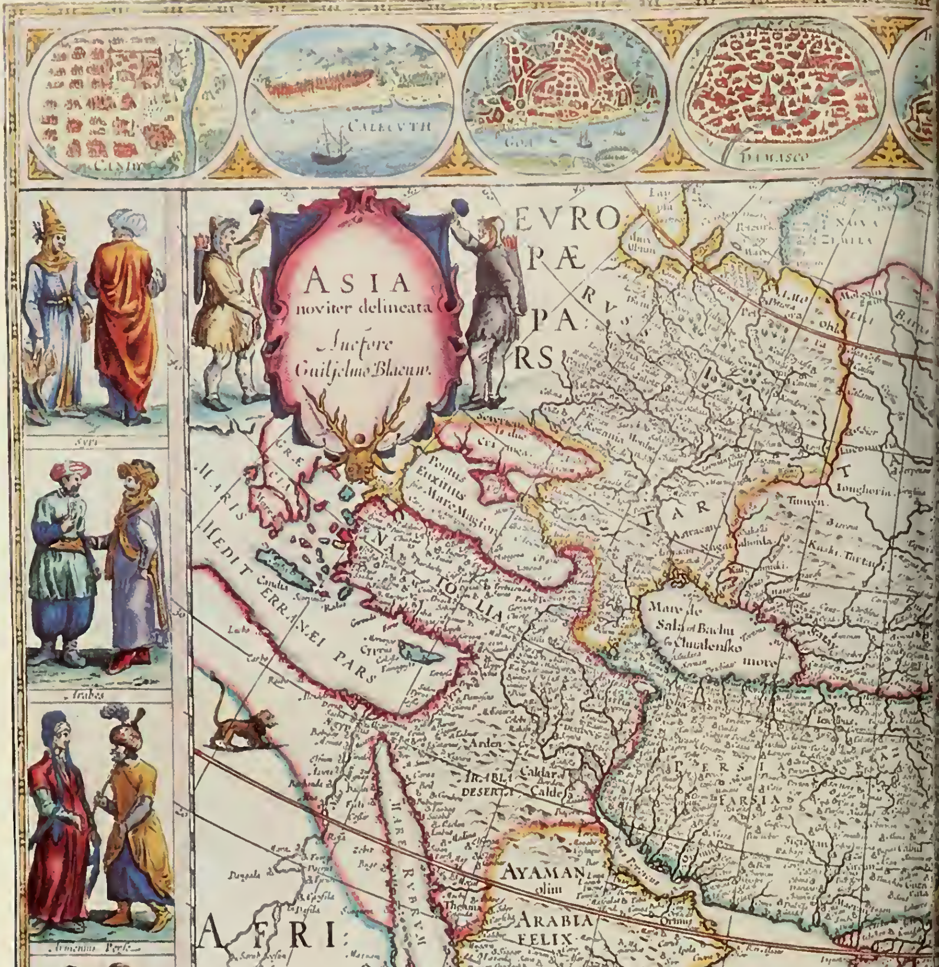
What is Asia? Most importantly, it is a landmass so vast that it makes Europe seem a mere promontory. The distance from Aden on the southeastern corner of the Arabian Peninsula to the Bering Strait in the north is 6,500 miles, more than 4,000 miles separate Cape Comorin from the Polovstrov peninsula on the Arctic Ocean, and from Baghdad to Peking it is 3,800 miles as the crow flies.

Asia fronts on three oceans and more than twice that number of seas, but despite this vast coastline, most Asians are landlocked and land oriented. Neither the Japanese, Chinese, nor Indians were seafarers. Not until late in Chinese and Japanese history did sea travel become important. It was the Koreans who braved the seas of China and Japan to transport merchandise and monks between the two countries. Similarly, Indonesians and Malays were often the sailors who brought Indians and Indian produce to Southeast Asia. Only the Arabs of western Asia made seafaring a critical part of their activity. Arab dhows reached Canton and traded as early as the eighth century A.D., and the ancestors of the Arabs carried the trade of Rome to India. A Roman seaport has been found at Arikamedu near Pondicherry on the Bay of Bengal.

Asia lends itself to isolation not only by reason of its great size but also because of the particular way it is divided by mountains and deserts. Mountains dominate Armenia, Georgia, and Azerbaijan. The Caucasus has always been a land of isolated, fiercely independent people who fought through the centuries to preserve their way of life in spite of efforts at conquest.

Land routes were the avenues of communication that counted for the Asians. The Chinese looked beyond their Great Wall to Turkestan via Dzungaria; the Indians looked to the Khyber and Gomel passes, on the border between modern Afghanistan and Pakistan; and the Persians to the northern roads from Turkestan to the Caucasus and the passes of the Zagros Mountains. But their own borders have had special meaning for Asian peoples. These lines were very important not simply as markers of territories but also because the people within the borders had ultrastrong feelings about their own lands. Chinese traveling abroad, for example, took a risk, for the Chinese want to be born and buried in the homeland of their ancestors. China, Korea, Burma, Thailand, Tibet, and Japan have all followed policies of isolation at one time or another, not only to keep foreign influences out but also as their peoples' expression of an inner devotion to the homelands on which their happiness seemed to depend.

*Prehistoric figurine from Baluchistan*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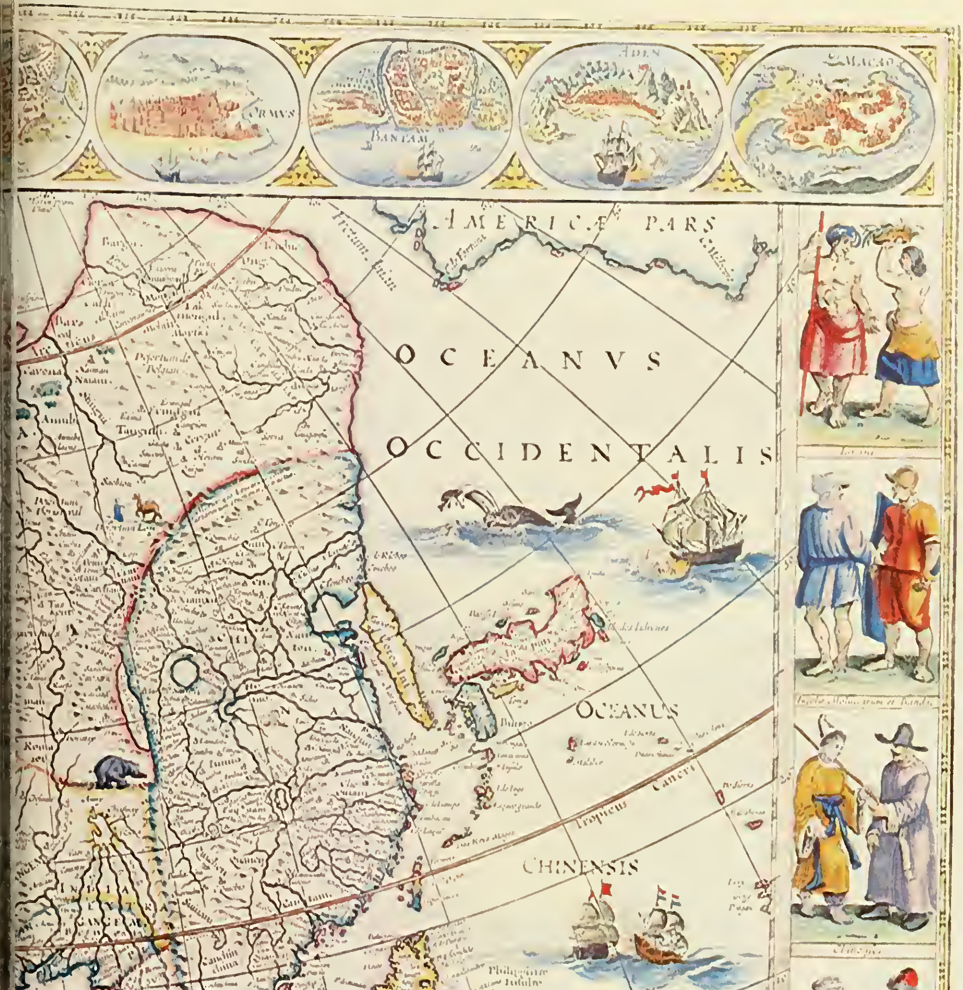
Courtesy of Map Division, The New York Public Library, photograph by Coxe-Goldberg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*Map of Asia made in 1662 by the family of Willem Janszoon Blaeu, Dutch cartographer and printer*

# The Near East

In many ways, Westerners find the people of the Near East more difficult to understand than those of any other culture area of Asia. There are two good historical reasons for this: Islam and the Turks. From the early sixteenth century until 1918, the Turks ruled much of southeastern Europe. Most of that time their empire controlled the whole North African coast and many islands of the Mediterranean. No one familiar with the history of Europe, particularly in the sixteenth and seventeenth centuries, can deny the enormous influence the Turks had on that part of the world. Their control of the eastern Mediterranean made trade with India and other eastern lands difficult, if not impossible. Expansion into Central Europe brought Hungary under Turkish control, and Vienna itself was beseiged. The most important seige took place in 1683 and is symbolized to this day by the crescent-shaped rolls found in all Viennese coffee shops. It took the combined powers of Poland and the Hapsburg monarchy to drive the Turks back, a victory that in European eyes represented the triumph not only of the Christian West but of the forces of good over those of evil.

The fact that polygamy was practiced in the Turkish Empire, that there were harems, despotic rulers, and an exotic aura to things "oriental," whether they were spices, bronze hanging lamps, exquisite rugs, belly dancers, or bedizened camels, emphasized the differences between East and West.

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Islam, the dominant faith of the modern Near East, is not only a religion; it is a way of life. The Word of God, as conveyed to men by the Prophet Muhammad and written down in the Holy Koran, is not altogether a doctrinal statement. It stipulates what the individual should be from birth to death, not directly in terms of the ideal, but as a practical statement rooted in the experience of living in the Near East. The remarkable thing about the Koran is that its practice leads eventually to that ideal.

For millions of people, Islam is simple to follow, and the promise of salvation it extends to those who follow it goes far beyond elaborations and rites. But to Europeans, the idea of the oneness of God, Islam's basic theme, subverts the Christian principle of the Trinity, for it denies the divinity of Christ although almost paradoxically accepting the role of Jesus as a prophet. Furthermore, the Koran does not oppose polygamy and indicates that a Muslim, that is, one who has submitted to God, has a duty to oppose non-Muslims.

To the West, the Koran was far from a holy book; it was a statement of paganism.

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Nearly 80 percent of Near Eastern people are involved in agriculture, so that populations concentrate heavily where agricultural activity results in large production. Thus cities such as Cairo, Damascus, Medina, Baghdad, and Shiraz are not only famed centers of religion, learning, and commerce but also viable centers in the areas of richest agricultural production. Such cities attract the products of pastoralists and here the hair, hides, meat, and rugs of pastoral enterprise are exchanged for manufactured objects and agricultural goods.

The characteristic city of the Near East is likely to depend for its wealth on commerce. Except for oil, the Near East generally lacks natural resources, and its oil has only recently been exploited. On the other hand, its geographical location between Inner Asia, Africa, and Europe gave the Near East a great advantage as a middleman. The local merchant class, dealing in products indigenous to the Near East or from regions far beyond, included wealthy patrons of a cosmopolitan culture that extended much farther than the confines of their own cities.

Connected, of course, with commerce are the splendors of Near Eastern craftsmanship. Through the

*Bronze bull head from Persia (ca. 1500–1300 B.C*

generations, families have generally carried on urban crafts. Characteristically, the shop is a retail outlet, a factory, and a place of residence. The crafts usually segregate along given streets or areas; thus streets of copper wares, rugs, basketwork, ceramics, jewelry, and cloth are an integral part of the typical Near Eastern city.

Near Eastern cities have specific architectural features that characterize them almost everywhere. The Islamic city usually centers on the mosque. It is not unusual to have a great central mosque and smaller ones spread throughout the city. Associated with the mosques are the religious schools. Near the great mosques are the central bazaars, or markets, which include storehouses and shops separated according to merchandise.

Beyond the bazaar are residential quarters divided by ethnic or religious affinity. Thus there may be separate quarters for Coptic Christians, Jews, Armenians, and Assyrians. Many of these quarters are walled, and within their confines people carry on the basic traditions of their own way of life. Outside the residential zone and the city walls are the vast cemeteries; many are concentrated around the tombs of saints or holy men and act as statements of mortality.

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Government in the past depended on the power of individuals or royal houses to impose their will on the countryside. It is not surprising therefore that the citadel, a fortification usually on a natural elevation, was often the symbol of government. Near the citadel, even perhaps surrounding it, was the royal city, which included the monarch's palace, the residences of the court, and the barracks for a military bodyguard.

*A silver Armenian flabellum, or fan, with bells*

Rulership in the Near East has been closely affiliated with religion. This was no less true in King David's day in ancient Israel than in the traditional Islamic country. At the heart of government is the *ulama*, a council of wise men representing various backgrounds, all of whom are trained in religion and can give advice on government. In some sense the council represents a link between the people and the leaders.

The Koran places great emphasis on the behavior of the individual. Everyone, whatever his or her secular status, is equal before Allah. Thus the judgment of the council is as much a comment on the individual as it is an interpretation of the Koran. It is not society that is responsible for the individual's actions, as Western man might argue; it is the individual himself. Accordingly, self-will, freedom of choice, and personal responsibility are as much a part of the Muslim's world view as they are for Christians or Jews.

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The largest percentage of the population of the Near East lives in the villages. Basically these villagers are peasants. Much of the village land, however, is not owned by the villagers but by the government or by landlords. High rentals and taxes and the vagaries of the seasons, which traditional technology could not deal with, have made village farming difficult. The villager is rooted to the land. Movement to escape difficulties is possible for the nomad but almost impossible for a villager. In consequence, villagers are exploitable, and more than any other group have been the most poorly off, as they have been throughout Asia as a whole. For this reason land reform has been one of the major developments for the revolutionary governments that have emerged since World War II.

The typical village is a group of mud-walled, generally flat-roofed houses, some two-stories high, irregularly placed about one another, and set within a walled compound into which animals can be driven in the evening. Groves of trees—date palms in the south; almond, walnut, pistachio, and poplar trees in the north—are part of the village landscape, providing both shade and fruit. The house usually consists of a kitchen, two sleeping rooms (or one divided sleeping room); a central social, or reception, room; storage rooms; ovens; mangers; perhaps a tower for pigeons; and sometimes a well in the courtyard.

The village is set in the midst of the fields. Because inheritance practices dictate that a man will bequeath some share of land to all his sons, the land becomes fractionalized; often a man may work one large field near the house and three or more much smaller ones scattered throughout the village holdings. A village mosque and perhaps a small schoolroom are the public buildings. The village well provides both water and a place for the exchange of gossip. Villages were once self-sufficient, especially when village potters, weavers, and smiths provided the necessities. Today, of course, manufactured goods produced by national industries, the use of money as the medium of exchange, and the pressure to grow

*Silver hair cones, from Oman area, filled with scented wool or cloth*

market crops have greatly reduced village self-sufficiency.

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Pastoral nomads are widely found in the Near East. They fall into two broad economic groups: desert Arabs who move seasonally across the Syro-Arabian desert, and mountain pastoralists who seasonally ascend and descend the mountain slopes, particularly those of the Zagros Mountains in Iran. The desert group emphasizes camels and some horses; the mountain group emphasizes sheep, goats, and cattle. Both groups place great importance on the abilities and prowess of the individual. Chiefs and sheiks retain their authority when they are successful as arbitrators, warriors, and possessors of economic wealth. Egalitarianism is particularly important, for the focus on the individual requires a role for those deserving a say in affairs. Chiefs thus spend a considerable period of time in consultation with the representatives of the men of the group.

In social organization the characteristic family is dominated by the oldest male, and it is through his line that inheritance passes. Among the Arabs, all married sons ideally live near the father, and through time a lineage develops relating each generation to a founding ancestor. These ancestral relationships also relate lineage to lineage, resulting in a collection of people who speak the same language, acknowledge the same ancestors, and seasonally follow the same pastoral routes. This large grouping, in turn, acknowledges a dominant lineage, that of the tribal chief.

The residential units of the desert Arabs are the camps in which the famous black tents are found. Made of goat and camel hair, the tents are divided into two parts—the one on the left for women, that on the right for men. Although women do the cooking, the men take pride in the preparation of coffee for which they have a special brazier and traditional implements. The sharing of coffee with strangers is a mark of hospitality.

The sexual division of labor is quite clear. Women do the domestic tasks; men take care of the herds. Raiding for camels and horses was standard practice among the Bedouin of Arabia; it was a means of regulating herd size and provided an opportunity for amassing wealth, which the normal growth of the herds did not permit. Seasonal movement is fairly strictly prescribed by adherence to traditional routes and pastures in both mountain and desert pastoralism.

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Many books have been written on the subject of the origins of the religions of the Near East—Judaism, Zoroastrianism, Christianity, and Islam. One thing is clear, no particular way of life was the genesis of these faiths. Quite the contrary, it was the mixture of many cultures that provided the setting for the birth of the ideas leading to monotheism and the relationship of man to a single God. The early civilizations of the Near East are marked ideologically by a pantheon of deities, all of whom, in one way or another, share the powers of nature. They created the world and all that is in it. Then man himself was created to work for the gods who disdain the daily activities of seeking subsistence.

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The most important development in the Near East after the division of the Roman Empire and its gradual demise was the appearance of Islam. The Prophet Muhammad (A.D. 570?–632), founder of the Muslim religion, was born in Mecca, in western Arabia. At the age of six, he lost his mother but, continued to live, apparently as a shepherd, close to his birthplace. Later in his youth it is thought that he worked on caravans traveling south to Yemen or north to Syria. He married a widow, Khadija, fifteen years his senior and active in the trade of which he was now a part. Apparently, even as a boy Muhammad had dreams of events difficult to interpret. He seems to have been a thoughtful, introspective person given to quiet contemplation of his world. It was a quarrelsome, warlike world, basically pagan and caught in the failings of the wornout empires of Sassanian Persia and Byzantium Rome.

It is certain that Muhammad found in the mountains surrounding Mecca the solitude necessary to give his thoughts focus. Just as Zoroaster perceived his vision of Man and God in the solitude of the desert, as Moses talked with God on Mount Sinai, and as Jesus saw the whole earth from the mountaintop in the wilderness, so Muhammad on the mountain Hira had a vision of the Archangel Gabriel and heard the Word of God. Filled at first with self-doubt and fearful of dreams of self-deceit, he remained silent while he wrestled with his convictions. At last he realized the reality of what had happened to him and began to preach of the oneness of God and his universality.

He preached of a final day of judgment; of man's individual responsibility for his own conduct under God. He required of all those who submitted to the God of Islam that they follow the teaching of the Koran by professing the Faith, the revelations of God that Muhammad affirmed as God's prophet. Fundamental to this teaching were five basic moral and ritual duties: to observe the Faith; to pray daily (there are five traditional times for this—sunset, night, dawn, noon, and midafternoon); to give alms out of mercy and charity; to fast during the daytime of the month of Ramadan, the month when the Koran was revealed; and to make a pilgrimage to Mecca (hajj) once in one's lifetime.

Mecca was a center of paganism in those days. Even the Kaaba, the Muslim holy of holies, was a pagan shrine. Because so many pilgrims came to this pagan center, its merchants prospered. Muhammad's antipagan preaching enraged the commercial rulers of the city, and they made every effort to stop him and his increasing number of followers. In the year 622 Muhammad and his followers fled to the city of Medina, a handsome place set in the midst of a date palm oasis. Muslims count their era from this hegira, or migration, from Mecca.

The years that followed were years of further preaching and of military campaigns that culminated in a return to Mecca in 630, which, as the place where the Word of God was heard, became a holy city. Now the band of converts grew and became a brotherhood to which Muhammad preached the laws governing the relationships between men and women under God. By the time he died in A.D. 632, much of the Arabian Peninsula had been converted to Islam. The government was no longer secular, and Islamic and political leaders had to submit to the authority of religious law. In fact, the head of the Islamic state was the Caliph, or defender of the Faith. To this day Koranic law influences government among the Muslim nations of the Near East.

After Muhammad's death a division occurred in the leadership between those who thought that caliphate succession should be selective and not hereditary, the Sunni, and those who felt that it should be hereditary. The latter picked Muhammad's nephew and son-in-law Ali and took the name of Shi'a, or partisan of Ali. Ali was murdered by the Sunni; later his sons Hasan and Husain were also killed. Ali's tomb at Najaf and Husain's at Karbala, both in Iraq, are among the holiest shrines for the Shi'ites. Shiism took hold in Iraq and, most notably, in Iran. The concept of the Imam, presumed to be a blood descendant of the line of Ali, assumes various forms in Shiism. Some believe that the Imam is divinely appointed and has succeeded Muhammad himself. Others believe in a second coming of a Mahdi (guided one).

Arab unity gave the Muslims a military capability, which, coupled with ever increasing numbers of converts from other regions, made possible the rapid conquest of kingdoms to the east and west. Their western expansion came to an end at the Battle of Tours in France in 732, one hundred years after Muhammad's death. After conquering Sind in the east and the southern Punjab in India, the Muslims seem to have run out of steam. All of the Near East except western Anatolia and Armenia was under Muslim rule.

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The history of the various countries of the Near East is one of invasion, particularly by the Turks and Mongols; of efforts to throw off the rule of the various dynasties; of periods of great cultural flowering; but never of a unity like that of the early years following the death of the Prophet.

Historically there seems to have always been an interplay between the pastoral nomadic discovery of self-identity and the sedentary farmers' need to integrate the old with the new. Whereas the farmer may respond by multiplying the complexity of his world view, the pastoralist seems determined to simplify it. The Bedouin Arabs' use of Islam to account for bad or good luck—and all things beyond their control—demonstrates an adaptability far beyond that of the sophisticated men of Cairo, Beirut, Riyadh, or Damascus, who grasp eagerly at Western ways by day and struggle for a reason to be at night.

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# India

For the West the story of the Indo-Pakistan subcontinent is dominated by the history of Englishmen who lived there over a span of more than three hundred years. Although the modern states of India, Pakistan, and Sri Lanka are justifiably proud of their political and cultural independence, for the Westerner it is Great Britain and her institutions that dominate and provide a temporal bridge to an understanding of those countries. All three states grew out of the colonial experience, which saw Englishmen come as traders and stay as rulers. During their stay, they brought the people of South Asia into the modern world. It is no small thing that English is the lingua franca of South Asia or that there are more than 800 words of Indian origin in use in the English language. The European experience in South Asia was by no means one-sided, however, for while English invention and organization brought to an end the feudal and ancient character of life in the subcontinent, Indian philosophy and crafts opened opportunities for new horizons to Europeans and changed the Western world view.

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Indians have a compelling sense of place within a larger structure. The energizing aspect of this awareness is bound up in the word *dharma*. Essentially *dharma* refers to doing what has to be done in one's life, not as drudgery or a labor of love, but as something necessary and right. *Dharma* was a major factor in Gandhi's peaceful resistance, which was critical in ending British rule in India. Gandhi considered violence not only demeaning in itself, since it endangered the order of life, but also un-Indian because it forced Indians to be what they were not intended to be—people who won their way by means of physical power. In his view, such victories could only lead to more violence. Much concerned with the relationship between morality and truth, Gandhi concluded that they were one and the same. If one acts morally, that is, with the sense of *dharma*, one's actions are truthful and enduring. What is morally obvious does not need the shedding of blood to make it so. In fact, bloodshed would only obscure the truth of India's natural right to be free. A free India was envisioned as made up of many parts, a building constructed of all kinds of materials but where each had an important place, the whole bound together by universal love. One cannot imagine the Mahatma's agony when in 1947 the British left India at last, and Muslims and Hindus slaughtered one another in one of the worst bloodbaths in history.

*Bronze lamp from Nagpur, India, in the shape of a seated bear with a bird's head*

In the sixth century before Christ, a king of Sakya, an Indo-Aryan kingdom in the foothills of the Himalaya, tried to protect his son and heir from the ugliness of the world. He created great pleasure gardens and surrounded the young prince with all that was desirable, all that could provide material happiness. Nevertheless, the prince saw human suffering in various forms, renounced the throne, and wandered over the face of India as an ascetic. After many years he realized that enlightenment would come, not through wandering, but through a struggle within himself. He took up that struggle, and sitting under a bodhi tree, he pondered the circumstances of life and death and the mortality of all living things caught in an eternal cycle of birth, death, and rebirth.

We know that prince as the Buddha, the Enlightened One. His answer to life's riddles—known as the Four Noble Truths—was simple: suffering exists, suffering is caused by desire, suffering can be overcome by the elimination of desire, desire can be eliminated by following the Noble Eightfold Path—a formula of moderation and clear thought, a statement of the role of reason in human affairs. The Buddha preached the application of his truths to all who would listen. After the Buddha's death at the age of eighty, Buddhism took many forms, but at heart it addresses itself to the human condition and a concern for all life.

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Hinduism, which steadily grew as the most important faith in India from a century or two before the time of Christ, also contains balanced views as to the responsibility of the individual for his own actions. The theme common to both Buddhism and Hinduism is the concept of rebirths. All living things are part of a perpetual cycle of existence, and nothing is lost no matter what form it takes. A basic reality in Hinduism is that man is not only responsible for his own actions but must fulfill the purposes of life whatever his circumstances in any particular rebirth.

There are four goals of man: the pursuit of pleasure, or *kama*; the seeking of material gain, or *artha*; the restraint necessary to do one's duty in life correctly, or *dharma*; and the eventual renunciation of the other three in order to be free from worldliness through a religious objective, or *moksha*. Of these goals, *dharma* is the most important since its emphasis on duty, justice, and rightness affects the pursuit of the other three.

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The *Bhagavad Gita* is for many the supreme statement

of Indian ideas concerning the place of man within the cosmos. A Hindu classic, it addresses itself to *moksha*, the fourth end of man. At heart it emphasizes the individual's personal relationship to divinity, the consequence of which is to bring that divinity into one's own actions. This enables one to fulfill one's obligations to society in the fullest possible way. The idea that those obligations may involve self-sacrifice is critical; indeed the point of fulfilling one's duty is not to obtain secular advantage or other material gain but to act for the good of society.

The *Bhagavad Gita* is concerned with the sayings of Lord Krishna, one of the most popular gods in India. Anyone studying Hinduism is immediately struck by the multiplicity of deities. Historically, much of that multiplicity was apparently caused by amalgams between the pantheistic Vedic tradition and the local beliefs of tribal India. However, the classical grouping of these gods has three main themes: creation (Brahma), destruction (Siva), and preservation (Vishnu). Paradoxically, each of these powers also contains its opposite. That is, Siva's destruction is also an act of preservation; similarly, Vishnu's preservation involves an act of destruction; and the implication of Brahma's creation is, of course, non-creation. Evidence for these divine paradoxes is found in Hindu mythology. Siva, for example, has consorts who are benign in appearance but also have savage demonic aspects. Vishnu is as capable of bringing fire and flood as of playing the flute for shepherdesses to dance to in some wooded glade. Vishnu's varied selves, or avatars, include Rama and Krishna among many others and are statements of his multifaceted character.

All of Hinduism's gods and goddesses require rites, festivals, and other devotional acts. This is in keeping with the idea of sublimating individual identity to the larger divine. The celebrated yoga (bhakti yoga), in which an essential element is meditation on "oneness," brings the individual into a direct relationship with "divinity." Esoteric Hinduism considers the individual self to be mere illusion in the context of the ultimate oneness, or universal self. To a very real extent every deity in the great tradition of Hinduism is like a key on a great cosmic organ; each produces a particular sound, a resonance if you will, that is a special sonant in the ultimate music of the spheres. The myths and legends gathered around these deities are the basis of narrative embellishments that are familiar to every villager throughout India.

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By far the largest number of Indians live in villages and the Indian village embodies the India of both dream and reality. Villagers till the soil of their forefathers, hoping for the monsoon rains to come in the terribly hot spring and hoping they will abate at crucial times in the humid summer. The village is dominated by a work ethic in which social recognition is gained through labor and the ability to fulfill one's role in the larger village society. Villages vary in plan and economic emphasis from one region to another. The Bengalis in the east and

*Carved wooden frieze features Indian goddess Gaja Lakshmi being annointed by elephants*

*Goat inlaid with silver and brass from early eighteenth century, north India*

the Tamils in the south are rice growers; the Punjabi of the northwest grow wheat. All try to raise garden crops of chilis, tomatoes, and other vegetables. Practically all village farms use bullocks for plowing and hauling. Cattle are respected for their divine derivation, and meat eating is a rarity, partly because meat animals are difficult to raise and partly because meat eating is generally regarded as an impure practice.

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Marriage in India has traditionally been arranged by a go-between who tries to obtain advantages for her employer. As in so much of Asia, marriage involves an economic and social exchange of value for both families. This often means that affairs of the heart are subordinate to the requirements of material considerations.

The position of Indian women is related to inheritance, which tends to go from father to deserving son, and to the customary authority of males in most village affairs. But in fact, the typical Indian village farming family is a work unit in which men and women labor side by side at harvest and seeding time or complement one another's work at other times of the year. Familial decisions tend to be based on discussion between parents, as they are in the West, and are determined by the practicalities of daily life. In terms of their position, Hindu village women tend to be far less bound by custom than their counterparts in either traditional China or the Near East. Older customs, such as child marriage and the isolation of widows, which made a second marriage impossible even though the girl might have been pledged to a boy in pre-adolescent years, have gradually been vanishing from the Indian scene.

Indian society is divided into *jatis,* or castes. The *jatis* can be regarded as functioning parts of the larger organism of Indian society. Each locale, whether village or city, has its own arrangement of *jatis.* A person is born into a *jati* and can never leave it.

In terms of religion, eating habits grade the *jati* according to levels of purity, with the purest being the Brahmans, who are exclusively vegetarian, and the lowest being those who eat meat or handle carrion. The origins of *jati* are not clear. What is apparent is that the number of *jatis* has multiplied greatly in the last three hundred years, mainly in response to changes brought about by contact with the West and by widened communications with the larger India.

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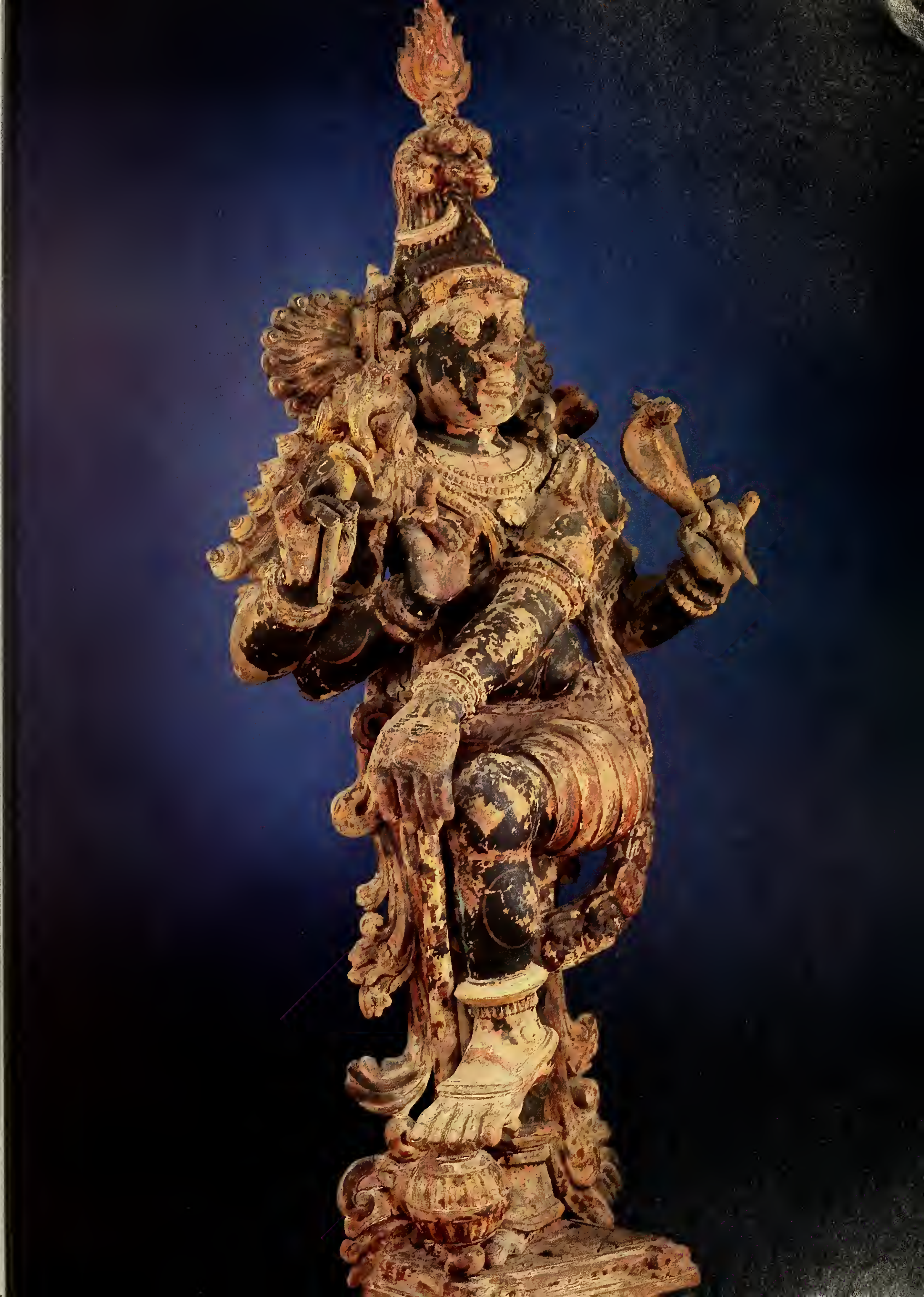
Much of Indian history is recounted in terms of north India where the foreigner continually set foot. South India, however, was never completely conquered until the British came with their ships. Village life began there about a thousand years before Christ and expanded into a civilized life as fine cities and towns developed, primarily for trade and royal administration. The Tamil poetic anthologies describe active princes, princesses, merchants, bards, soldiers, musicians, and all the specialized activities common to urban civilization.

The Muslim conquest of northern India, which began with the Arab conquest of Sind in the eighth century and reached its climax with the Mugul empire beginning in the sixteenth century, struck a powerful blow at native Indian traditions. But with a tenacity that still marks India today, much of the tradition survived. Nonetheless, the Muslim-Hindu confrontation has never been peaceful. The anti-Hindu policies of many Muslim governments left a split between different peoples that continues to divide India and the Muslim state of Pakistan. Yet this was not always true. For the Muslim rulers in India had to accept the idea that to rule successfully one had to rule with justice—not simply justice for Muslims but justice for all. Some rulers made valiant efforts to do just that. The most notable was the great Mugul ruler Akbar, a contemporary of Elizabeth I of England and a deeply religious man who listened to followers of many faiths, including Christianity. His policy of tolerance led to greater harmony than had generally been found before in the Muslim state. Akbar demonstrated that given understanding and legal rights, Hindu and Muslim could get along harmoniously.

The Muguls left other, material monuments, as well, the Taj Mahal being the most famous. Based on Persian design, it is significant, however, that the Taj has become one of India's best-known symbols. It is as if the Mugul emperor Jahan had built the Taj Mahal not so much as a tomb for his beloved but rather to provide something beautiful in homage to the Hindustan over which he reigned. That same sense of mission is felt in the history of British India, for looking at the accomplishments of the British Empire in India, one finds that many British officials, realizing that British control could not last forever, wanted to leave an India that would be a monument to their justice and understanding.

*Painted wooden statue of Rudra, an ea*
*Vedic god of storms and lightning who evolved into S*



# China

To be Chinese is not simply a matter of birth or location, but an acknowledgement that one is part of a stream of consciousness that originated in an idyllic, remote past, has flowed through many vicissitudes down to the present, and will continue to flow in the future. To be Chinese is to be privileged, not because the rest of the world is barbarous, although many Chinese have espoused that idea, but because China is so enduring as to challenge mortality itself.

The outsider gets an initial impression of China as a series of vivid contrasts: the brown green countryside with drably dressed working people counterposed against the brilliant colors of street processions and the interior walls of temples or halls, an enormous mass of humanity contrasted with the solitary figure of a sage in a Taoist painting amidst flourishing trees and pristine, cloud-suggesting mountains, the calm quiet of an old man's bearded face radiating the wisdom of a special maturity, and the singsong wail of the actor in the Peking Opera or the "clack-clack" of a street vendor's wooden cymbals in the early morning. The smells of China are the heavy odors of night soil, fish, and jasmine contrasted with the ephemeral aromas of fine tea, dark timber, and sandalwood.

Above all, there is the endless land. Land is China's measure of value, for what produces food feeds the populace and what is not productive causes famine. There is no escape from that equation in a country with the world's largest population. Those who would understand China must start with the Chinese farmer, his family, and his land. The social cohesiveness of the large family was both an economic and an ideological virtue and caused the Chinese to congregate wherever soil and water allowed them to subsist, rather than to fan out in small households across the landscape. Even in Confucius's day, when the population was much less than a twentieth of what it is now, northeast China was crowded with large families that remained for centuries in one or two places.

With a technology of hand tools and plows and carts drawn by animals or humans, every member of the family had a role. Men and boys broke the soil; women and girls did the seeding and harvesting. In general, every effort was made to keep the large, extended family together.

Directly related to the intimacy of humans and the land was the traditional contempt the Chinese have had for the soldier and the merchant. Neither of these occupations results in foodstuff or the permanence of the family. In the classical Confucian view, the merchant is a nonproducer seeking his own profit. The soldier has uses, but if he is killed far from home, he cannot observe filial piety. Nothing represents China's contemporary Westernization more dramatically than the rise of standing armies and the creation of a military elite.

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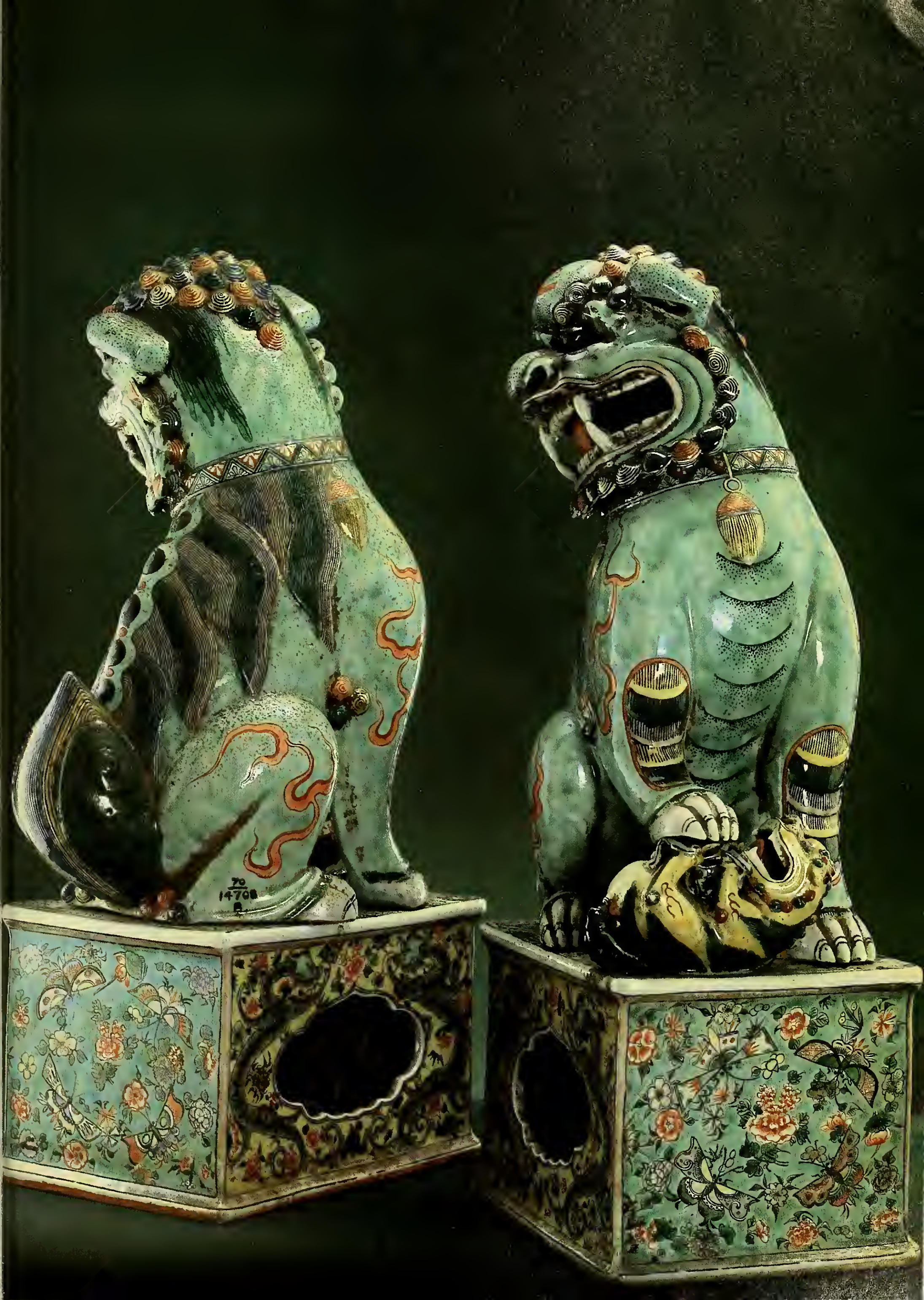
The Chinese sage Confucius lived at a time of great trouble for China, from about 551 to about 479 B.C. It was the latter part of the period often referred to as the "classic age" because of the number of writings important to the Chinese tradition that were composed or compiled by famous men of the time. Confucius appears to have been a thoughtful, observant youth who was increasingly troubled by the civil wars and other problems brought on because the central authority was no longer strong enough to control the warring barons. Basic to Confucius's thinking was the idea that the peace and prosperity of the early part of the classic age had been brought about by ideal rulers who modeled their authority on the natural harmonies of the world. In other words, to bring order out of disorder the people of China had to look back to the time when there had been order. Confucius obtained the books of rites and rituals used by the early rulers and brought them to the aristocracy. He insisted that the ancient rites be observed to the letter. More than this, since a ruler was expected to keep the ideals of the past before him, he must accordingly behave morally toward his subjects. His greatest obligation to the people was to gain their confidence. To do this he necessarily had to keep their needs steadily in mind, just as a father must always keep his family in mind if it is to flourish.

This familial relationship is basic to the Confucian ideal. The family in any individual's life must have a central place. When familial relationships are extended into society and sustained by the same qualities that make them vital within the family unit, the society will be harmonious and the state to which that society belongs will be free from disorder. The Confucian system therefore contains five basic relationships. Three are familial: father to son, husband to wife, and older to younger brother. One relationship is social, friend to friend. The final one relates to the state, ruler to subject. These relationships depend ultimately on mutual respect, but it is a respect that can only come from the self-cultivation of virtue. For those who would rule, the emphasis had to be on education.

An essential ingredient of the familial relationships is filial piety. This refers to the respect of children not only for their living parents but for their ancestors as well.

*Nineteenth-century porcelain watchlions from north Ch*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The traditional Chinese concept of self can be depicted as a familial chain stretching between the remote past and the near future. The individual is one link on the chain. He owes his being to the past and is thus responsible for assuring a future for his family line. Since the Chinese family is patrilineal, it traces its descent through the male line. Thus sons must marry and produce male offspring so the family name and property will be perpetuated. The most unfilial thing a son can do is fail to produce sons, for that endangers the perpetuation of the family name and thus denies respect for the ancestors. The ideal Chinese household, according to the Confucian ethic, is one in which many sons and their wives and children live under the same roof.

In point of fact, there was great difficulty in keeping married sons together because they could not all inherit the family land. If the land were divided equally among inheriting sons, each share would become progressively smaller through succeeding generations. A common practice was to award the property to the oldest son or sometimes to the most able one. This son then became responsible for the others. However, the other sons, desiring land of their own, probably moved away to establish homes of their own. Wherever those sons went, they nevertheless continued to observe filial piety for the founding ancestor of the family through ceremonies and virtuous acts designed to honor the family generally, and they raised their children within the familial tradition. From this practice of perpetuating the family name even when living far from their place of birth came that important element of Chinese life—ancestor worship.

*Oxblood porcelain vases of the Ch'ing dynasty (1644–1912)*

"Ancestor woship" does not literally mean the worship of an ancestor as though he were a god. Rather, it is a ritualized way of honoring one's predecessors, involving incense burning, prayer, and offerings before an altar containing wooden tablets on which the ancestral names are written. The altar was either in an individual's home or, in communities where numerous related families resided, it might be in a separate building, known as the ancestor hall, that housed the family records and ancestral tablets. These halls are architecturally splendid community buildings that may contain images of Taoist or Buddhist deities or saints. Here the affairs of the community might be discussed by the village elders. The rich colors—gold on red, gold on black lacquer, soft blues, pinks, and vivid greens—coupled with the lavish use of ideographs and traditional designs, make ancestor halls a striking relief from the rather drab buildings of the typical Chinese village.

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Buddhism was well established in China by the fourth century A.D. but early on encountered both Chinese ethnocentrism and the deep-seated Chinese belief in the relativity of present life to what was and is. The esoteric aspects of Buddhism as practiced in India, however, did not take hold among the people of China, for ideas of reincarnation and Nirvana were not consistent with the linearities of the Chinese ancestor cult. What did take hold was the form of Buddhism known as Pure Land. This conceives of an infinite number of Buddha worlds, one of which is ruled over by the Buddha Amitabha. This is a paradisiacal world often depicted in Buddhist painting as a place of glorious palaces and splendid gardens where the blessed exist in peace and happiness. According to simple practice one could attain that blessed land by invoking Amitabha by merely uttering his name. The temples and monasteries of Chinese Buddhism were filled with the iconographies of the Pure Land and meditation upon that land was customary.

This manifestation of popular attitudes toward religion marks the story of China after the classic age. Buddhist, Taoist, and Confucian beliefs became all mixed up with Chinese local beliefs in ghosts, spirits, and mythical creations. Dragon lore originates in the observance of the vitalism in nature that is central to Taoist belief, and soon there are dragon kings, boats, deities, and a dragon of the sky that chases the sun and moon at the New Year.

To face the realities of this world the Chinese enlisted a host of supernatural helpers. For although man is indeed the link between heaven and earth, past and future, there is no question that the factors of fortune and misfortune are the chance elements in an otherwise logical world. The famous I-Ching, or *Book of Changes*, acknowledged for thousands of years as one of the most important books on man's place in the cosmos, deals directly with the factor of chance. The I-Ching, in effect, not only measures chance but by so doing sets forth predictabilities far more meaningful than the law of averages of the West, for they relate to wisdom itself. No wonder that popular Chinese religion uses the hexagrams of the I-Ching almost as frequently as gold-on-red characters for good fortune and happiness.

*Ho-tei, the Chinese god of good fortune (nineteenth centu)*

# Japan

Japan is the end of Asia, beyond it lies the vast Pacific Ocean. Situated on the eastern fringe of that great continent, Japan through its culture expresses both its rich debt to the great traditions of China and India, which historically have influenced it, and its own indigenous mastery of cultural self and of what it has received. Japan was one of the last regions in Asia to receive civilization. Its culture is peopled with historical ghosts that roam the landscape—for example, winged creatures with human faces like the *tengu*; little devils like the *oni*; and lonely shades of the mountains. The country has had a powerful military tradition and a monarchy that has endured to the present. It has a rich literature with a great tradition of poetry.

The people of Japan were often thought by others to be less the originators of ideas than their instruments. The Industrial Revolution found ready acceptance in Japan, the most industrialized Asian nation. That development is a tribute to native genius. Modern Japan presents a picture of slick and efficient enterprise.

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Japan is a beautiful country, consisting of four mountain-crowned islands surrounded by ocean and sea and extending over fifteen degrees latitude. Its crescent shape links it with Korea and eastern Siberia, yet it touches neither. Subject to earthquakes and tidal waves, Japan is no quiet, sea-girt paradise, but a land of great contrasts: high mountains and stony beaches; volcanoes and sandy littorals; rock promontories in the sea and mossy stones in clear streams; pristine green forests and untold miles of rice paddies. By day Japan feeds the eye and provokes the mind; by night there are elements of darkness and light that motivate the sensitive to remember the past.

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Consciousness of the past is an element of the Japanese spirit. Unlike the West, where conceptions of earlier times are dominated by great figures such as Pericles, Alexander, Charlemagne, Elizabeth I, and Napoleon, the Japanese tend to think of the past in terms of events and of dynastic families. They have their own pantheon of great men—warriors, rulers, priests, artists, and thinkers—but almost all of these individuals are regarded as products of a time rather than creators of it. In this sense, history for the Japanese has a kind of logic that emphasizes durability through time rather than uncertainty and the vagaries of direction caused by individual personalities. Like the earthquake-prone countryside, Japanese history sways with the movements of events but remains paradoxically stable. There were no foreign rulers, no Mongol or Manchu dynasties. But there has been repeated struggle between local rule and centralized government; opposition between parties of secular and of sacred authority. There are conservative champions of tradition and progressive proponents of newer ways of doing and thinking. Yet one senses in Japanese history evolutionary rather than revolutionary qualities.

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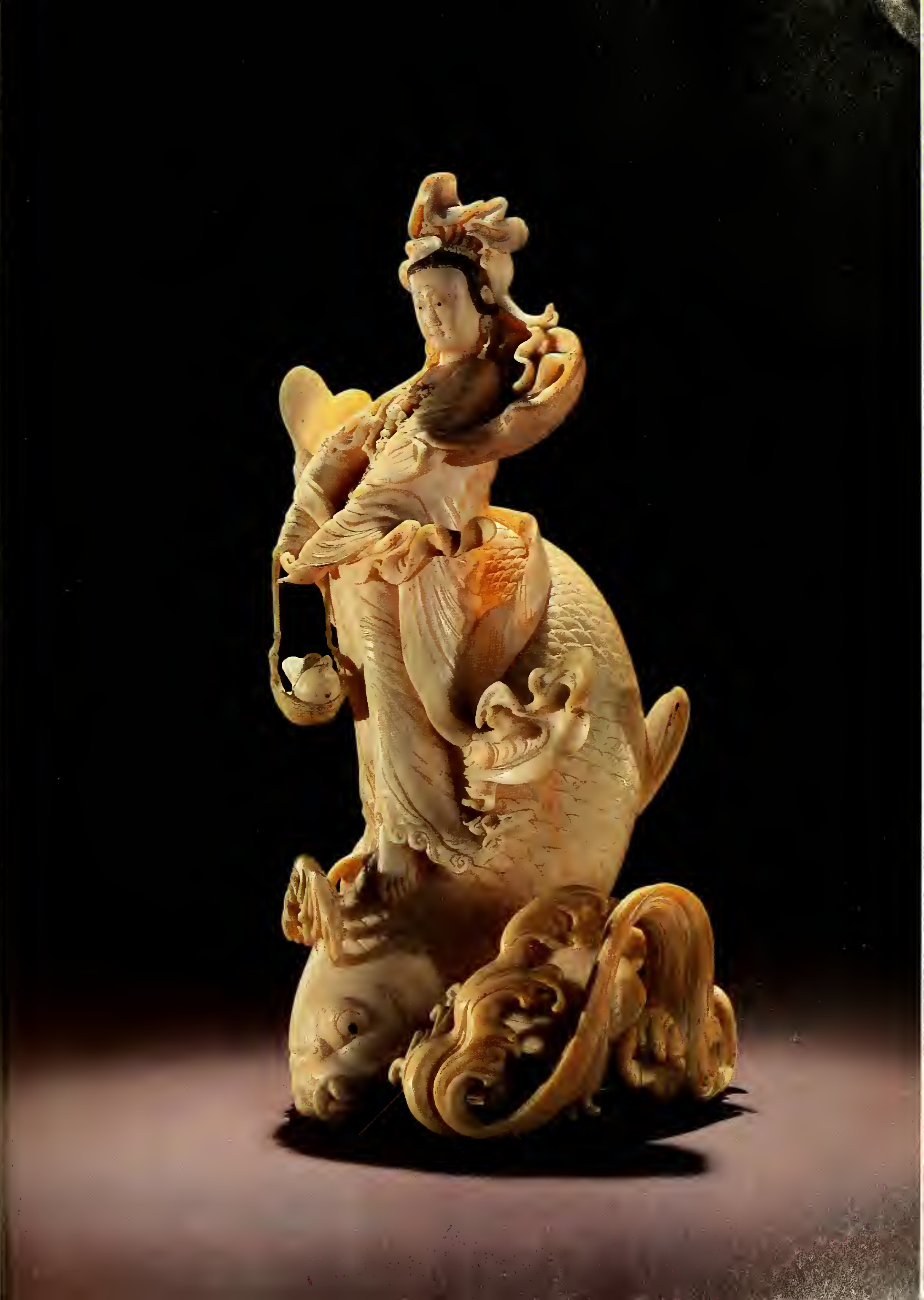
About A.D. 1200 some four hundred years of Japanese feudalism began. Ostensibly receiving their authority from the emperor, the local shoguns, or military governors, operated fairly much on their own volition. This warrior society, which was the dominant force of medieval Japan, can be summarized by the term samurai (one who serves). The samurai were characterized by courage, military ability, intense loyalty to leaders, and a personal pride that often amounted to arrogance. As provincial warriors they presented a great contrast to the courtiers of the imperial court in Kyoto. The wars, intrigues, and successions involving the samurai are the basis of some of the most popular stories known to the Japanese. Like the cowboy stories of the American West, many modern Japanese concepts of history are samurai centered.

Despite the emphasis on combat during the long period of military domination, many shoguns and their provincial governors (*daimyo*) were patrons of the arts. Painting, like that of the world-famous fourteenth-century landscape painter, Sesshu, and architecture, such as that of the Gold and the Silver Pavilions, are outstanding. The No theater, the tea ceremony, and even landscape gardening gained great prominence. Whereas in the previous Fujiwara court there had been an increasingly rigid aesthetic etiquette, the feudal age was looser and permitted innovation.

The tension between local self-rule and central authority had a paradoxical quality in that no matter what individual convictions were held, everyone acknowledged the divine roots of the imperial line. The natural tendency of the Japanese was toward unification, not separatism. This played a role in the success of a series of powerful leaders in eventually reunifying and

*Ivory carving of Kwan-Yin, the Japanese godde*
*of mercy and protectress of fish and fisherm*



ruling Japan. Of these leaders, the best known were the Tokugawa, a family that controlled Japan from 1603 to 1867. An active class system placed the samurai at the top, followed by farmers and artisans, with merchants at the bottom. Fearing a growing European presence and the challenge of Christianity to Japanese values, all but a few Europeans and Chinese were excluded. This policy of exclusion effectively isolated Japan from the West for more than two hundred years. But those were years of considerable development: cities and towns grew, agriculture expanded, and money became the means of exchange.

The cultural innovations of the feudal period flourished as never before. Puppet theatre, Kabuki, and haiku poems illustrated with woodblock printing appeared. Costumes marking rank and occupation and a preoccupation with ornamentation and fanciful calligraphy made even the simplest shop in the market a firm statement of form and color amidst a tasteful riot of decorated street signs, lanterns, parasols, and door posts. This was the Japan of the floating world, of pleasure quarters, of the geisha, of the love suicides. It was a world where Confucian ideals were introduced into government to insure purpose and longevity.

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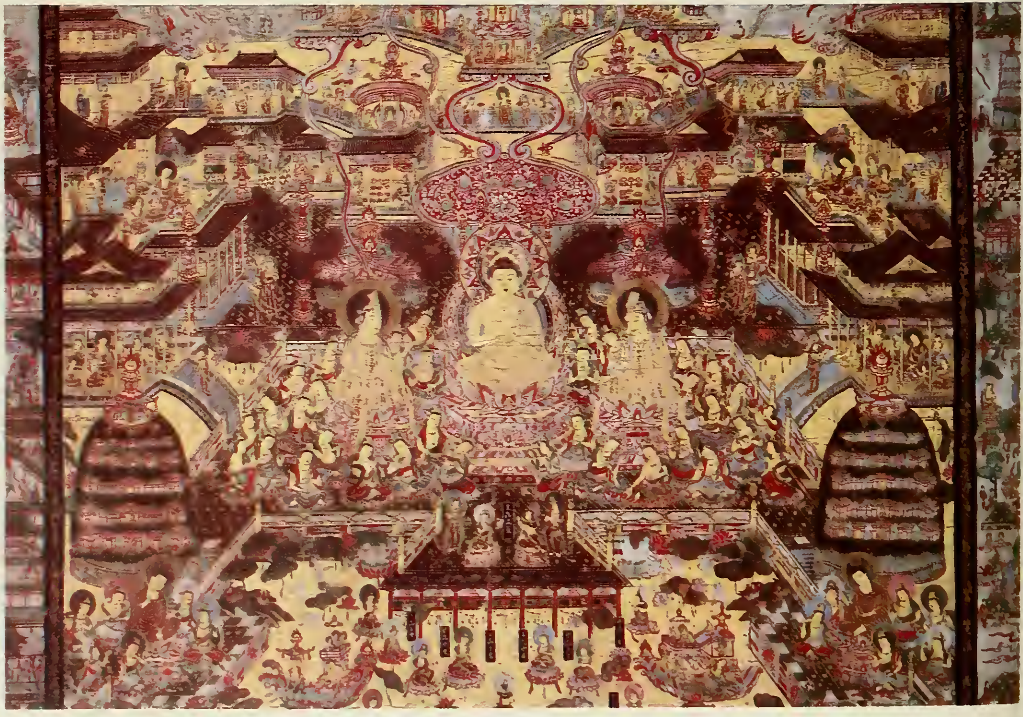
The fall of the Tokugawa was presaged by two oddly contradictory factors. Under the Tokugawa the samurai had nobody to fight. While they had high social status and rights possessed by no other social class, they tended to be impecunious followers of lords whose success depended not on arms but on farmers or merchants. Samurai poverty motivated the arts of Zen Buddhism, the tea cult, and the miniature austerities of flower arrangement and landscape gardening. For these arts are not expensive. Rocks, sand, flowers, crudely made tea cups, lonely meditation, and the linking of poetic lines are available to even the poorest person. Refined taste, sensitivity, and the search for a richness beyond the material are all that one needs.

The other factor was the success of the merchant group, the lowest within the class structure. The growing cities and towns, the tight controls of Tokugawa administration, and the fundamental social and political order of the day were ideal for the role of the merchant. The exchange of goods and services by merchants was necessary if the townspeople were to enjoy the foodstuffs, cloth, metal, ceramic, paper, and wood necessary to city life. The raw materials of the craftsman, the finished products of the artisan, and the markets necessary for their distribution could not be the responsibility of samurai. They were untrained in such matters and considered them socially demeaning. The merchant class grew in wealth while remaining low in social standing; the samurai grew poorer while remaining high in social status. Samurai often found themselves in debt to the merchants and there was acute discomfort in the situation. Unable to handle the growing needs of its people, the Tokugawa shogunate sought reactionary answers, including excessive taxation of the peasantry and military ways to control local recalcitrance.



*A Japanese mandala, or meditative religious painting, dating back to 1491*

# JAPAN THE SECOND TIME AROUND

**"The first time Jim and I were in Japan we spent three days there. It wasn't nearly enough time. We promised ourselves we would come back. I'm so glad we kept our promise.**

"We started planning our trip months before we were in Japan. Looking back now, every minute we spent planning rewarded us in hours of enjoyment.

"Even though we never met them, Jim and I feel we have many friends at the Japan National Tourist Organization. They not only sent us guides, timetables and maps, they went out of their way to answer special questions. For example, Jim just finished reading Shogun and wanted to see something connected with the samurai warrior era. JNTO told us we could visit the house of a samurai in Matsue and Hagi. JNTO even helped us arrange a visit with a Japanese family through their Home Visit Program.

"We chose Japan Air Lines because we wanted our vacation to begin as soon as possible. On JAL, we felt we were in Japan from the moment we were welcomed aboard with the traditional bow. Their gracious, thoughtful service was a precursor of our whole vacation. JAL also opened a world of special information to us—lightweight travel handbooks and a Jet-Age language cassette in traveller's Japanese that Jim mastered very quickly. And when we told JAL of our interests in ceramics and gardens, they quickly recommended a tour that highlighted both.

"Our trip has given us a wealth of memories: the tame deer we fed in Nara, the ikebana flower arranging class I took, the village of pottery craftsmen we visited where we both had turns at the potter's wheel.

"Jim and I are back home and planning for another trip to Japan."

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Nevertheless, discontent continued to grow until, with the coming of Commodore Perry in 1854, the Tokugawa system began to fall apart. It ended in 1867 and was replaced by the centralization of a new imperial system and the restoration of the emperor to central authority. Brought out of the secluded court at Kyoto, the then emperor, Meiji, moved the imperial seat to Edo, now known as Tokyo.

The two recalcitrants of feudal Tokugawa times, the samurai and the merchant class, brought Japan into the modern world, and in the name of the emperor, made Japan a world power. But in the end their ambitions nearly destroyed the country in World War II.

□

Shinto is the ancient native religion of Japan. The term *Shinto* means the "Way of the Spirit, or Kami." Kami can be conceived of as a benign and elevated spirit in a world of spirits. It is at once personality within things and a quality counter to the destructive, or bad luck, elements in life. Although the Japanese are conscious of a dualism in nature, it is never as sharp as the Yin-Yang of Chinese Taoism. The Japanese myth of creation emphasizes not so much how the world was created as that it was created in order to make Japan possible.

Shinto offers believers a means of relating to the elevated qualities of life. For an artist, it can be the glimpse of a pattern in nature; for the peasant, the well-being induced by rewarded work. Kami can be as specific as the particular shape of a teapot or as general as the good fortune of being born Japanese.

Shinto's relationship to the emperor made possible the state Shinto prevalent in Japan from the Meiji period up to the end of World War II. When the Mongols attacked Japan in the thirteenth century, typhoons drove them away. The Japanese believe these great rescuing winds were sent by the gods. Gods are manifested in Shinto as animistic personalities encompassing the divinity of Japan's kami origins. The winds were called *kamikaze*, "spirit wind," a term later applied to Japanese pilots who flew suicide missions in World War II secure in the knowledge of the divinity of their role. Up to that war, Japan had never been conquered and it seemingly had a mission related to its divine origins. After World War II state Shinto was abolished, but Shinto today is unquestionably still the national faith of Japan. It is a religion to live by, for its purpose is to promote the best in nature. Almost by definition the kami of Shinto is what gives good things their goodness, and what defines the finer qualities of life.

□

Another element in Japanese identity is knowing one's place. In Tokugawa times, class divisions were rigidly imposed. One could not marry out of one's class. Whole patterns of behavior were specified for each class—the depth of bow, the way one looked or did not look, and the language of honorific forms, which differed from class to class. This had the effect of creating a social and economic system in which everyone had a place, a manner, and a daily role with specific goals to fulfill. The Tokugawa social system was a caste system with emphasis on role playing and the maintenance of a characteristic Japanese sense of order. However, there were individuals outside the caste system. Like the untouchables of India, they could do menial tasks and were for all intents and purposes treated as slaves.

□

The Japanese family has been a Confucian family ruled by the father and with descent through the male line. All property remains with the oldest son. This has caused even greater difficulties in Japan than in China because of the extremely limited availability of land. With the growth of population during the Tokugawa period, drift to the cities and towns took place. This required shifts in class status. Brothers or sons of farmers could not be farmers in cities. Thus numerous people attached themselves to merchants and to whatever industries or service units were available. The Tokugawa attempted to force the peasantry to stay on the land but, in the face of population pressures, they were only partially successful. Although filial piety was respected, the Japanese rarely developed the ancestral depth and ritual of the Chinese.

Women in Japan have had little or no authority, even within the family. Subservience to the authority of the oldest male has been the rule. Formality exists between husband and wife, and social activity takes place primarily between males. This has often made the geisha the only woman to whom men could speak openly. Contrary to popular belief, the geisha is not a prostitute, but a cultivated individual trained to entertain with wit, song, and dance. Her role is to provide the otherwise lacking female companionship.

Children, of course, made the family more cohesive. They were raised to fulfill the role already laid out for them: the strict spartan upbringing necessary for samurai, the daily tasks of the farmer, the apprenticeship of the artisan. Grandparents, with their ties to past ways of doing things, gave children a sense of tradition that reinforced the work ethic and above all established the manners and customs of social relationships. Probably no Asian nation, or indeed any nation of the world, had as formal a prescribed manner of social behavior as the Japanese. But with Westernization, the class divisions and, along with them, the strict behavioral patterns broke down. Yet even in the face of change, the Japanese sense of social position remains strong and respect is still displayed to the elderly and those in authority.

## Coda

All cultures have their reason for being. What cultures do, what form they take, and how they survive is the result of how well they function for those who have created them. It then follows that the myriad cultures of traditional Asia are at best the effective responses of particular societies to the circumstances in which they have found themselves. These circumstances include not only adaptation to given ecological situations but also the cumulative responses to traditional histories in which cultural adaptation to indigenously motivated change, as well as integration with outside alien influences, has taken place.

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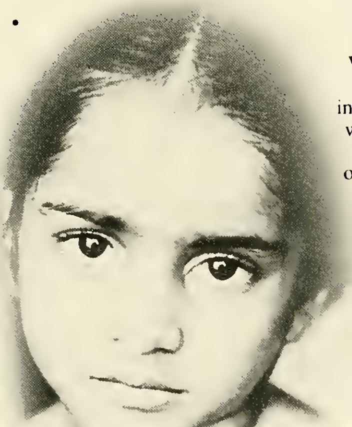

**After Mangala's father died, Mangala, her two sisters and her mother moved in with relatives. Ten people are now crowded into a 10 x 18 foot house. No electricity. No furniture. They must carry water from a community tap, a tap that is turned on only two hours a day. Mangala's mother works in a factory, but she cannot earn enough to provide even the basic necessities. Mangala now has a Foster Parent. Others are still waiting.**

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We hope you will join with us in offering a needy child a better life. Because even sadder than their need is our knowledge that we *could* help. If . . .

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# The Gardner D. Stout
# Hall of Asian Peoples

In the new Gardner D. Stout Hall of Asian Peoples, a gilded eighteenth-century Buddha sits peacefully in the Japanese section. His serene aspect is in marked contrast to the noisy activity all about him as electricians, painters, artists, preparators, and others work furiously to complete the hall by its scheduled opening date, October 17. This hall, one of the largest and most ambitious in the Museum's history, is the culmination of 14 years of planning and construction and 111 years of collecting.

The Hall of Asian Peoples was a natural outgrowth of the Museum's extensive collection of Asian ethnographic material, most of which was assembled from 1870 to 1920, the golden age of Museum expeditions.

The Jesup North Pacific Expedition (1897–1903) was probably the most important in the Museum's history and certainly the most significant for the new hall. It was organized and financed by Morris K. Jesup, a founder of the Museum, to investigate "the theory that America was originally peopled by migratory tribes from the Asiatic continent." The expedition traversed Siberia, Manchuria, and China, enduring the –50°F temperatures of the Siberian winter, the Boxer Rebellion, and the Russo-Japanese War. One of the expedition's leaders was Berthold Laufer, a great believer in the value of a culture's material objects. He would often walk into workshops and stores and buy everything in sight, including items that were not originally meant to be sold. He even bought out entire drugstores and assembled a representative selection of foods. The Jesup expedition acquired the contents of thirty-five shops and a collection of Siberian ethnographic objects that remains the finest in the world. When a Soviet delegation recently toured the unfinished hall, they were astonished at the range and quality of the objects in the Siberian section. "We have things," says Walter Fairservis, Jr., research associate in the Department of Anthropology and scientific consultant for the new hall, "that even they don't have."

Other Museum expeditions excavated paleolithic sites in the Gobi Desert and other sites in Mongolia, and explored India (bringing back, among other things, much of the portable contents of three Indian villages), Afghanistan, Japan, Tibet, Iran, Korea, and China. The Museum also acquired other large Asian collections, including the Whitney collection of Tibetan religious objects and the Drummond collection of Chinese and Japanese jade and ivory carvings.

Because the Museum did not have a large Asian hall, most of the objects went directly into the storerooms of the Anthropology Department. Fairservis recalls the excitement of "rediscovering the collection" as curator of the new hall. For example, tucked away in a vault under the eaves of the Museum, he found several boxes of extremely rare movable metal type from Korea that predates the Gutenberg Bible by 100 years. And in the Siberian collection, he found a nineteenth-century pictographic love letter written on birchbark.

Fairservis, however, found that the quality and the great number of artifacts were as frustrating as they were rewarding. "There was a lot of stuff upstairs that I just hated to leave out. Less than 5 percent of the collection is actually on display. We have, for example, about 4,000 beautiful Chinese and Indian shadow puppets and room to display maybe a dozen at the most.

"Space was our biggest problem. How do you present all of China in its vastness in something like eighty running feet? We even left out whole cultures. I'm sometimes awed by our audacity."

"The point of the hall," Fairservis continued, "is not simply to show beautiful objects as an art museum would, but to tell a cultural story. This is an anthropology hall, and our approach has been holistic. We want to give visitors an understanding of Asia—its cultures, value systems, cycles of life, social organizations. We

were very careful to get the input of Asian nationals, both as consultants and as artists."

To reflect the diversity of Asia, the Hall of Asian Peoples was designed to wind through numerous corridors, alcoves, and rooms. Visitors with a knowledge of Asian geography, however, will have no trouble finding their way since a journey through the hall follows the two major routes through Asia. One route starts in the ancient city of Samarkand and moves through the Near East, India, Southeast Asia, China, and Japan; the other begins in Siberia and traverses Central Asia and Buddhist High Asia.

"You can actually trace your journey on a map of Asia," says Alex Williams, the hall's designer. He explained that each of the eight principal regions of Asia is set apart by a particular color scheme and traditional architectural styles, and in most sections visitors will hear the traditional music of the area. A separate section illustrates prehistoric Eurasia and the rise of civilization.

One day last summer we toured the Hall of Asian Peoples to see how things were coming along. Picking our way through ladders, stacks of lumber, coils of wire, and sheets of Plexiglas, we suddenly came across a view of seventeenth-century Samarkand, at the crossroads of Asia. The painted scene depicts the overflowing bazaars of the central plaza, shimmering in the heat and surrounded by domed palaces. Kneeling on plywood scaffolding above the diorama, Museum artist Frederica Leser was painting a traditional Islamic pattern on an archway. From her Michaelangelic perch, she talked about her work.

"These elaborate designs," she said, tracing with her finger the complex of intersecting lines and motifs, "could drive one to distraction. It took me quite some time to find authentic Islamic patterns and figure out how to adapt and transfer them to these arches.

"The previous project I worked on involved painting the reptiles in the Hall of Reptiles and Amphibians. As you can imagine, this was quite a change. All of us working on the new hall have had to be versatile."

From Samarkand we moved on to the next section of the hall, which features Islam. Here we ran into Matthew Kalmenoff, an artist who has been with the Museum for thirty-five years, working on a huge painting of the city of Mecca. The scene shows thousands of pilgrims streaming into the holy city at dawn; in the background a crescent moon rises. Kalmenoff has painted, among others, many of the backgrounds in the Hall of North American Forests. He described his technique: "A background must have a feeling of depth and space. I break the painting up into a progression of color planes extending to the horizon. This gives the feeling of looking off into the distance."

Kalmenoff then showed us one of his completed paintings, the background for an exquisite nineteenth-century Chinese wedding chair inlaid with kingfisher feathers. "You don't want the background to compete with that chair," he said. "You can see—look closely—how I have broken the colors into dots to give a sense of light—a Monet feeling. I work closely with the electricians, who have to follow my color scheme when doing the lighting."

Kalmenoff has painted many of the backgrounds and scenes in the hall, including Samarkand, Jerusalem after a thunderstorm, the Great Wall of China, the palace of the Dalai Lama reflected in a mountain lake, Jericho in about 6500 B.C., Troy and the Dardanelles, and the hanging gardens of Babylon.

"But my happiest painting," he says, "is Samarkand. Those rich, rich colors. You don't get any schooling for this kind of work. Most of the backgrounds are curved surfaces, and the color values and linear perspective

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Europe
Iceland: 16 days, June 12, July 3 & Aug. 7 • Islands & Highlands of Scotland: 23 days, May 29, July 10 & Aug. 21 • Spain: 18 days, Apr. 17 & Sept. 4.

Asia and Africa
Indonesia: 24 days, July 14 & Sept. 8 • The Himalayas: 25 days, Mar. 19 & Oct. 8 • India: 21 days, Jan. 31 & Oct. 31 • Sri Lanka: 18 days, Feb. 19 & Nov. 19 • Kenya: 23 days, Feb. 5, July 23 & Oct. 22.

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Australia & New Zealand: 30 days, Jan. 31 & Sept. 19 • New Zealand & the Milford Track: 22 days, Feb. 20 & Nov. 13.

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change with the curvature. To make the paintings, especially their architectural details, look natural, is very difficult."

During our tour, we were struck by some of the more unusual aspects of the hall. Alex Williams departed from traditional Museum design in several respects, especially in the use of innovative lighting and modern painting styles. Williams commissioned Frank Mullins, the late artist who did covers for *Sports Illustrated*, to paint abstract and semiabstract backgrounds for several sections of the hall.

Most Museum-goers will find their first visit to the hall somewhat overwhelming. But it is hard to imagine how a Hall of Asian Peoples could accurately reflect its subject and not be overwhelming. Says Fairservis: "It would be wrong to give visitors the feeling that they had somehow 'seen' all of Asia, and it would be arrogant to say the hall 'encompasses' Asia. I believe, however, that the hall does give a fair statement of Asian values."

We asked Fairservis what he hoped to accomplish with the hall, what his goal was.

"The key to the whole hall," he replied, "lies in what it does to inform. There is in the West a real ignorance of Asia. If we look at our Asian foreign policy over the last forty years, we see a history of ignorance and inertia. We won't admit there are concepts

The Museum is planning a number of events in conjunction with the opening of the Gardner D. Stout Hall of Asian Peoples. Listed below are some of the special Asian programs planned for the fall. Look for more information on future programs in the "At the American Museum" column of *Natural History*.

**Fujian Hand Puppets from the People's Republic of China**

On tour for the first time in North America, a troupe of eleven puppeteers from the province of Fujian, China, will present four performances of the traditional Fujian hand-puppet theater. The troupe performs plays based on classical Chinese literature, and its members manipulate the foot-tall puppets with surprising agility. The puppets, carved in wood and dressed in richly brocaded costumes, smoke pipes, drink tea, fly through the air, and even spin plates on their heads. The Fujian puppets, presented through the Asia Society's Performing Arts Program, will be in the Museum Auditorium on Thursday and Friday, September 4 and 5, at 7:30 P.M., and Saturday and Sunday, September 6 and 7, at 2:00 P.M. Tickets may be purchased at the door, for $12.50 ($7.50 for members). Call 873-1327 for ticket availability.

**Civilizations of Asia**

Walter Fairservis, Jr., scientific consultant and curator for the Gardner D. Stout Hall of Asian Peoples, will give an evening lecture series entitled *Asian Civilizations*. In four slide-illustrated lectures, Fairservis will survey the major traditional cultures of Asia, from China to the Near East, focusing on religion, family life, language, and history. *Asian Civilizations*, which begins October 23, will run for four Thursday evenings, from 7:30 to 9:00 P.M. Series tickets are $20. For other offerings in the Evening Lecture Series, refer to the "At the American Museum" column in this issue.

**Ravi Shankar**

The well-known Indian sitarist and composer Ravi Shankar will give a lecture-demonstration of Indian music on Wednesday, September 10, at 7:00 P.M. in the Auditorium. He will play and discuss his music, and answer questions from the audience. Tickets are $6 ($5 for members) and may be purchased at the Auditorium door. Call 873-7507 for ticket availability.

**Films on Asia**

On four weekends in October and November, a series of free films on Asia will be shown in the Auditorium from 2:00 to 4:00 P.M. Each weekend will feature a different culture: October 18 and 19, India; October 25 and 26, Japan; November 8 and 9, the Himalayas; and November 15 and 16, China. Films include John Nathan's *Farm Song*, about the life of a rural Japanese family; a 1935 film by C.S. Cutting, *Beyond the Forbidden Frontier*, the earliest footage of life in Tibet; and three 1980 films on life in the People's Republic of China. For a complete schedule of films, write to the Education Department.

**Theater of the Deaf**

In December, the Education Department and the Touchstone Center will present *The National Theater of the Deaf*. Four deaf actors and one hearing actor will present a theater piece based on the life of Issa, the Japanese haiku poet. This free program is especially suited for young people. Look for more details in the December issue of *Natural History*.

and suppositions about the world other than our own. I feel a certain basic anger."

In the afterword to a book Fairservis is writing about Asia (excerpted in this issue), we find a passage that seems particularly appropriate to the new hall:

> Perhaps we of the West in the end will see and learn there were other ways of life not so long ago—indeed some still struggle to survive—and that these other ways were and are as valid as our own. Perhaps then in the perspective of Asian accomplishment we might find presuppositions other than our own materialistic ones and realize other courses to human happiness.

*Douglas J. Preston*

**Asian Arts**

The People Center will offer seven weekends of programs on Asia, starting October 18 and 19. The free programs, which run continuously from 1:00 to 4:30 P.M., will feature the traditional arts, crafts, music, and dance of India, Japan, China, Buddhist High Asia, Korea, and the Near East.

**Margaret Mead Film Festival**

The 1980 Margaret Mead Film Festival is also featuring several programs on Asia, including films and commentary on Iran and premières of several films on China. Look for details in the "At the American Museum" column of this issue. For a program of films write to the Department of Education.

**Gallery Talks**

Museum visitors are invited to attend several free one-hour gallery talks on the Hall of Asian Peoples. Participants will tour the hall with Museum instructors and learn about the great civilizations of Asia. *Introducing the Gardner D. Stout Hall of Asian Peoples* will be given on November 6 and 18 and December 4 and 16; *The World of Islam* on December 9; and *Asian Textiles* on December 30. All gallery talks start at the first floor Information Desk at 2:00 P.M.

**Holy Land Before Christ**

Claireve Grandjouan, professor of classics at Hunter College, will give a slide-illustrated lecture entitled *The Holy Land before Christ* in the Auditorium on Wednesday, December 3, at 7:00 P.M. Grandjouan will discuss how recent archeological finds shed new light on the history of the Holy Land. Tickets are $4.00 ($3.00 for members) and are available through the Education Department.

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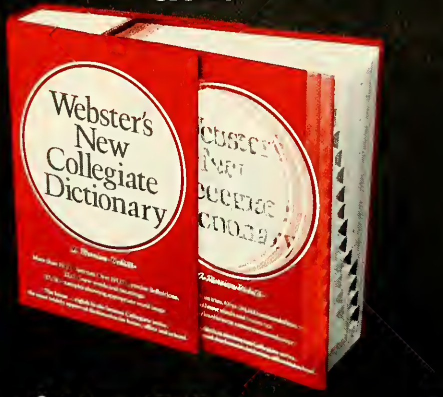

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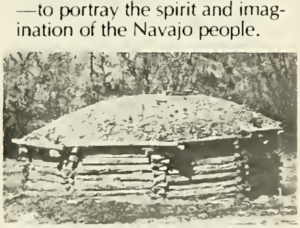

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# Plants of Prey

### by Stephen K-M. Tim

CARNIVOROUS PLANTS, by Adrian Slack. *The MIT Press, $19.95; 240 pp., illus.*

Lush greenery in botanic garden conservatories always seems to evoke the same inquiry: Where are the man-eaters? Fertile minds once wrote of hand-picked maidens being sacrificed to fanciful plant life in the jungles of way-beyond. These vivid tales live on and continue to coax the imagination of modern man. However, there is little excuse for ignorance about carnivorous plants these days. Illustrated articles in popular magazines and highly refined cinematography have enabled our appreciation of these plants, which derive nutriment from the breakdown of insect bodies, to transcend the sensational.

The past decade has seen a phenomenal surge in the popularity of carnivorous plants. *The Carnivorous Plant Newsletter*, born out of the dearth of reliable information about growth requirements and availability, came into being in the United States in 1972. Its goal was the dissemination of interesting yet scientifically correct information. It was only logical that books would follow and this was precisely the case. These appeared from a number of countries, including Japan, the United States, and Australia. *Carnivorous Plants*, which made its debut in Great Britain in 1979, has now been made available through the MIT Press. The author is landscape architect and plantsman Adrian Slack, who has been captivated by these plants since childhood, but a number of American specialists assisted in the book's compilation.

The volume covers the world's genera of carnivorous flowering plants, emphasizing the most distinctive and better-known species. Descriptions have been kept as nontechnical as possible and a brief glossary clarifies unavoidable terminology. Since the traps of these plants are among the most specialized structures in the plant world, descriptions dwell on these to a large extent. Coverage bears upon the action of the trapping procedure and follows the system adopted by F.E. Lloyd in his book, *The Carnivorous Plants* (1942). Plants with passive traps are distinguished from those with active traps, which display some movement in the entrapment process. The avoidance of description by family makes the book less clinical. The author has not neglected the decorative aspect of these plants; the abundant and colorful flowers of the butterworts are a surprise when compared with those of the pitcher plants, whose bizarre flowers and complex pollinating mechanism seem suited to such unique plants.

The pitcher-type trap, a highly modified leaf, figures most prominently in the passive forms. Through a series of drawings, Slack presents a hypothesis for the origin of the funnel-shaped, pitcher-type structure. Such a trap is an ideal reservoir for water, and some species have evolved a variety of overarching hoods, or flaps, which serve to attract prey or act as an umbrella, preventing rainwater from diluting the fluid in the digesting chamber or washing out the prey. Elaborate mechanisms to lure insects into the "recesses of unlikely return" have appeared in different

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Jana Gata

*Drosera binata*

ways. Insects, enticed to explore the open rim by a "bait" of nectar secreted by strategically positioned glands, often plummet into the watery depths. The tropical pitcher plant, *Nepenthes*, for instance, has loose, waxy secretions, just below the inside rim of the pitchers, that clog the footpads of normally sure-footed ants. Little wonder these traps are often filled with the empty bodies of these insects.

Further action in the pitchers follows one or a combination of two processes. In the case of the sun pitcher, *Heliamphora*, and the cobra lily, *Darlingtonia*, bacterial action within the watery medium is solely responsible for the breakdown of the soft parts of the insect. In contrast, in the trumpet pitcher, *Sarracenia*; the tropical pitcher plant, *Nepenthes*; and the West Australian pitcher plant, *Cephalotus*, the fluid first becomes acidified, enabling a protein-digesting enzyme, similar to that found in the human stomach, to act on the prey's softer tissues. The nutritive fractions are then assimilated through the walls of the pitchers.

Three other genera are covered in the passive section. Of these, *Genlisea*, the least well known, is not widely cultivated at present. This is surprising, considering the wide distribution of the species. The other two, *Byblis* and *Drosophyllum*, are both equipped with abundant, shimmering mucilaginous glands on their narrow, tapering leaves. The sticky fluid will smother struggling insects and digestive enzymes do the rest. *Drosophyllum*, the Portuguese sundew, is atypical among the carnivorous plants; it inhabits dry, often alkaline rocky outcrops in Spain, Portugal, and Morocco, whereas almost all other carnivorous plants are confined to acidic environments in freshwater bogs or other wet to moist situations.

Slack was unconventional in not describing the species with active traps first. Whatever the reason, if indeed any was contemplated, his approach does force the reader to get away from the common association of carnivory in plants with movement, particularly that encountered in the popular Venus flytrap.

In an overall survey of the plants in the active section, only two families are found, the Lentibulariaceae (bladderworts and butterworts) and the Droseraceae (sundews). Yet, so varied are the members in each family that one might be tempted, at first glance, to consider them unrelated. Although they are in the same family the butterwort, *Pinguicula*, and the bladderwort, *Utricularia*, differ greatly in form. Minute, sticky glands cover the rosette of broad leaves in *Pinguicula* and smother very tiny insects. A slight inrolling of the leaf margins justifies the placement of *Pinguicula* among the active traps. In contrast, *Utricularia* is endowed with numerous, highly complex, and sophisticated traps in the form of tiny submerged bladders. Each bladder is under negative pressure internally until a small insect, usually a water flea or nematode, stimulates the sensitive trigger hairs around the periphery of its inwardly opening door. This causes the one-way door to suddenly swing open, and the resultant inrush of water sweeps in and traps the unsuspecting prey. Digestion in both the butterworts and bladderworts is by enzymes.

Jana Gata

*Sarracenia leucophylla*

In the sundew family, equally striking distinctions among the members are obvious. The well-known Venus flytrap, *Dionaea*, with its two-lobed trap and spinous outgrowths that interlock when the trap is sprung, needs little introduction. It remains one of the most spectacular of carnivorous plants that "perform" at the macroscopic level. In contrast, the sundew, *Drosera*, has numerous, sticky, gland-tipped tentacles covering mainly the leaves; these tentacles and most of the leaf itself curve over the prey, making full contact with it. Glands, in both cases, secrete enzymes. The characteristics of *Drosophyllum*, a member of this family covered earlier in the passive section, further emphasize the variety within this one family. Two other genera, *Aldrovanda* and *Polypompholyx*, are also included among the active members.

A striking feature of the book is the black-and-white and full-color photographs, the product of the highly skilled artist Jane Gate. The dramatic portraits complement the text in a thoroughly meaningful way. I was especially impressed with one black-and-white photograph of *Sarracenia minor*; the two hooded traps, with a pair of ants feeding on bands of nectar around the open lips, illustrate an unusual food chain—the impending demise of the ants, themselves drinking in the nectar, and the resultant enrichment of the plants. My only criticism here concerns the lack of habitat studies; the environs of carnivorous plants are often as specialized as the diverse plants they spawn.

The culture of these plants is confined to a separate section. Temperature, light, and humidity requirements are clearly outlined and growing media for each species are recommended. Propagation is also covered in depth. May I offer a few points of clarification here. When artificial light is used for growing, the daylight tube alone provides an insufficient spectral range and should be combined with, at least, a warm white tube. Slack does advocate combining the daylight tube with one of the fluorescent plant-growth lights as an alternative. Secondly, I would like to underscore the

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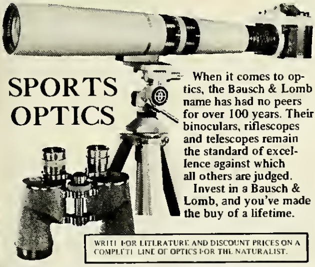

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author's reservations about precluding ventilation in greenhouses in warm climates so as to maintain a high humidity. In such cases, ventilation and the use of fans to encourage air circulation are essential to reduce the incidence of plant disease. Finally the fumigant BHC, recommended for plant pests on *Drosera*, is banned in the United States and an alternative insecticide must be used.

Unfortunately, of the many errors scattered throughout this quality publication, a number were not picked up in the book's listing of errata; these range from spelling errors to taxonomic misrepresentation. As an example of the latter, the use of single quotation marks with *Drosera* 'Bannister' indicates a registered cultivar name. However, this is an acknowledged temporary name until the plant (it is said to be a new species) is validly described. Until then, double quotation marks should have been used, hence: *Drosera* "Bannister." Lastly, a small point: There was a tendency toward anthropomorphism in descriptions involving the capture of prey but I must admit that this is my own personal aversion, particularly where carnivorous plants are concerned.

In our present world, specialized specialists are becoming the order of the day. Once there were gardeners; now there are specialist gardeners. In the study of the carnivorous plants there are already many "one genus" specialists, so a book that covers the subject widely—and attractively—is a most refreshing and welcome reference tool that will fill many gaps in the available literature.

Today the future of many carnivorous plants is in jeopardy; their numbers diminish as their often fragile habitats are plowed under and developed. Commercial exploitation of wild species and, sadly, the removal of these plants by unthinking hobbyists are equally to blame. Perhaps the influence of books, such as this one by Adrian Slack, which not only informs so invitingly but also stresses reserve where collecting is concerned, will encourage conservation through education.

*Stephen K-M. Tim is taxonomist at the Brooklyn Botanic Garden where, in 1974, he assembled a collection of carnivorous plants for display. He lectured in botany at Rhodes University in South Africa before coming to the United States.*

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# The 1980 Margaret Mead Film Festival

When films . . . are functioning at their best, the people in them seem bearers of the immeasurable wealth and effort of human experience.

David MacDougall, *Principles of Visual Anthropology*

The late Margaret Mead's concept for the first Margaret Mead Film Festival in 1977 was to bring the rich variety of human experience to a general audience through one of her favorite anthropological tools—the camera. Faithful to Mead's ideal, the 1980 Margaret Mead Film Festival will again enable interested people to meet filmmakers and anthropologists and take part in discussions of their work.

This year the festival honors the filmmaking team of David and Judith MacDougall. Graduates of the UCLA Film School, the MacDougalls have made nearly a dozen films in Africa, Australia, and the United States. They will show and discuss four of their recent films on Wednesday and Thursday evening, October 1 and 2.

In 1973/74 the MacDougalls spent fourteen months with the Turkana of East Africa: eleven months getting to know them and three months filming. They often spent twelve hours or more per day with their subjects, their camera always in filming position. David MacDougall says, "I lived looking through the viewfinder. But because the camera ran noiselessly, my subjects soon gave up trying to decide when I was filming." The Turkana finally resumed the normal course of their lives, allowing the filmmakers to record intimate scenes "without embarrassment or pretense on the part of the subjects."

The MacDougalls plan a trilogy of films from the 35,000 feet of film they shot in Africa. The second and latest in the series is *Lorang's Way*, which will be shown on Wednesday evening, October 1. Through conversations with Lorang and glimpses of him with friends and family, the MacDougalls show us a dignified, complex man who views his society as vulnerable and whose traditional role has been reshaped by that realization. *Under the Men's Tree*, a second, much shorter film that the MacDougalls made on an earlier trip to Africa, will also be shown. This film records an interesting case of "reverse ethnology" as a group of Jie cattle herders in Uganda discuss the industrialized world's great status symbol, the automobile. Laughing among themselves, they go over the qualities of cars and the relative worth of cars and men.

In 1975, David was appointed director of the film unit of the Australian Institute of Aboriginal Affairs,

*Workers in a commune from* North China Commune *(première October 4, Auditorium)*

National Film Board of Canada

*Hortense and Christina Miller appear in* Quilts in Women's Lives *(October 5, Gallery 3)*

Debra Heimerdinger

**Signs or Sentences?**

Herbert Terrace, who raised the famed chimpanzee Nim Chimpsky and tried to teach him sign language, will give a free slide lecture entitled *The Grammatical Capacity of Apes* on Wednesday, September 24, at 7:30 P.M. in the Auditorium. This program is presented in cooperation with The New York Academy of Sciences.

**Evening Lecture Series**

For those interested in anthropology, natural history, geology, and botany, the "Adult Evening Lecture Series" is an excellent opportunity to broaden your knowledge. Series topics this fall include *Asian Civilizations*, taught by Walter Fairservis, Jr., scientific consultant for the Museum's new Gardner D. Stout Hall of Asian Peoples; *Archeology Today*, taught by David Hurst Thomas, chairman of the Department of Anthropology; and numerous other subjects, from sociobiology and animal behavior to wildlife drawing and mineral identification. Write to the Department of Education for a course brochure.

**Courses for Stargazers**

The Hayden Planetarium is offering a large selection of courses in astronomy, navigation, and aviation for both adults and children. The Planetarium is also planning *Cosmos*, a special twelve-week course based on the television series written and presented by Carl Sagan. *Cosmos* will be taught by Lloyd Motz, professor of astronomy at Columbia University, and will explore numerous scientific topics from a humanistic perspective. The course will take up such subjects as the theory of relativity and the creation and evolution of the universe. A catalog and application may be obtained by writing to the Hayden Planetarium.

**The End of the World**

*The Planetarium All-Stars Show* opens Monday, September 8, at the Hayden Planetarium. This live sky show presents the current sky, its constellations, the motions of its planets, and other astronomical events. On September 25, *The End of the World* opens. Sometime in the future the world must end. How it will end—whether by the death of the sun, collision with a comet or asteroid, the coming of a new ice age, or nuclear Armageddon—is open to debate. *The End of the World* takes a dramatic look at present-day theories.

**Workshops for Young People**

The Education Department has again prepared a series of *Workshops for Young People*. The courses are designed to give hands-on experience with science to children in grades 4 through 7. Five workshops—covering topics in anthropology, natural history, and animal behavior—will be offered. Contact the Education Department for a course brochure and application.

**Discovery Tours**

The Museum is offering a tour of the Galápagos Islands and the highlands of Ecuador in June 1981. John Bull, a Museum ornithologist, and Charles Cole, a Museum herpetologist, will lecture on the diverse and unusual species of birds and reptiles found in these areas. For further information about the 1981 Museum travel program, write to Discovery Tours.

and Judith, film assistant. Two films that resulted from the MacDougalls' work with the aborigines of Aurukun, Queensland, are *The House Opening* and *Familiar Places*. These films, which will be shown on Thursday, October 2, look at different aspects of the aborigines' adaptation to, and conflict with, European ways.

In addition to presenting their views on filmmaking and various theories of ethnographic film, the MacDougalls will discuss working together as a husband-wife filmmaking team.

Series tickets for the two evenings with David and Judith MacDougall are $10 ($8 for Museum members) and may be purchased in advance from the Education Department.

On the weekend of October 4 and 5, the free films and discussions will cover an eclectic range of topics—from Chinese communes to the black experience. Many anthropologists and filmmakers, including Jean Rouch, Ray Birdwhistell, Alan Lomax, and Catherine Bateson, will be on hand to introduce and discuss the films.

One of the festival's major programs will première four films on the People's Republic of China. Shortly after the United States and China normalized diplomatic relations, an American film crew was given permission to interview and film in areas previously closed to the West. On Sunday, October 5, these three filmmakers, Sue Yung Li, Shirley Sun, and Peter Wang, will screen and discuss their films, *Suzhou* and *Beijing*. *Suzhou*, set in the traditional environment of canals, gardens, and silkworm farms, explores the city, its people, and their values. *Beijing* looks at the former imperial capital, and through interviews and scenes of daily life, shows how the political, social, economic, and cultural changes of this century have influenced the lives of the people. The filmmakers interviewed, among others, Pu Jieh, the brother of the last emperor of China, who reminisces about his youth in the imperial court and compares it with his present role as a representative in the People's Congress.

On Saturday, October 4, *North China Commune* and *North China Factory*, made under the aegis of the National Film Board of Canada, will be introduced by the filmmakers, Tony Ianzelo and Boyce Richardson.

Another major program, *Perspectives on Iran*, features two Iranian films never before shown in the United States. Anthropologist Catherine Bateson, Margaret Mead's daughter; William Beeman, an anthropologist who lived in Iran throughout the recent revolution; and Bahman Maghsoudlou, an Iranian filmmaker, will discuss these films and what they can teach us about Iranian culture.

Although this year's festival includes a number of classic ethnographic films, its emphasis is on new films. One film that caused a sensation in Australia when it was released last year was *The Last Tasmanian.* The Tasmanian aborigines, who had lived in the same area for at least 23,000 years, were wiped out in less than 75 years by disease and genocide. The film traces the fifteen-year search of anthropologist Rhys Jones, who pieced together a picture of the last Tasmanians—their culture, technology, artifacts, and swift extinction.

Other programs making up the 1980 Film Festival are *Recent Landmarks*, *Film for Research and Teaching*, *Dance-Drama in Java and Thailand*, *Soviet Ballet*, *Latin American Faith and Ritual*, *Dogon Funeral Ceremony*, and *Black Experience*.

Programs will be distributed at the Museum's entrances before and during the festival.

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Fee: $20.00

**Dr. Walter A. Fairservis, Jr.,** Professor of Anthropology at Vassar College and Research Associate in the Museum's Department of Anthropology, uses color slides to survey several major cultures of Asia, from China and Indo-Pakistan to the Near East. Religious systems, family life and history are examined in the context of intercultural influences. This series coincides with the opening of the Museum's Gardner D. Stout Hall of Asian Peoples, for which Dr. Fairservis was scientific advisor.

**ARCHAEOLOGY TODAY**—4 Mondays starting October 20, 7:30-9:00 p.m.
Fee: $20.00

Archaeology has undergone a technological and a theoretical revolution in the past decade. In illustrated lectures, **Dr. David Hurst Thomas**, Associate Curator and Chairman of the Museum's Department of Anthropology, explores several of these breakthroughs. "Classic" and contemporary expeditions are used to provide a broad overview of the questions asked by archaeologists and how they provide answers.

**GEOLOGY OF NEW YORK**—4 Tuesdays starting October 21, 7:00-8:30 p.m.
Fee: $20.00

This slide-illustrated series explores the geological history of New York. **Sidney Horenstein**, a staff member in the Museum's Department of Invertebrates, discusses New York's Foundation Rocks, Ice Age New York, Landscapes and Ecology, and Building Stones—New York's other Geology.

**SOCIOBIOLOGY**—6 Tuesdays starting October 21, 7:00-8:30 p.m.
Fee: $35.00

**Dr. Ethel Tobach**, Museum Curator of Animal Behavior, examines arguments for and against the theory of sociobiology as an explanation for the human condition. Using some of the Museum's exhibits as well as live animal demonstrations, Dr. Tobach will explore the implications of these controversial questions.

**WILD FLOWERS OF THE NORTH**—6 Thursdays starting October 23, 7:00-8:30 p.m.
Fee: $30.00

**Helmut Schiller**, Lecturer in Botany at the Museum, explores with slides the world of wild flowers of northern mountains, coniferous forests, and wetlands, from Alaska and the Pacific Northwest to New England.

**EXPLORING AMERICAN WILDERNESS AREAS**—6 Thursdays starting October 23, 7:00-8:30 p.m.
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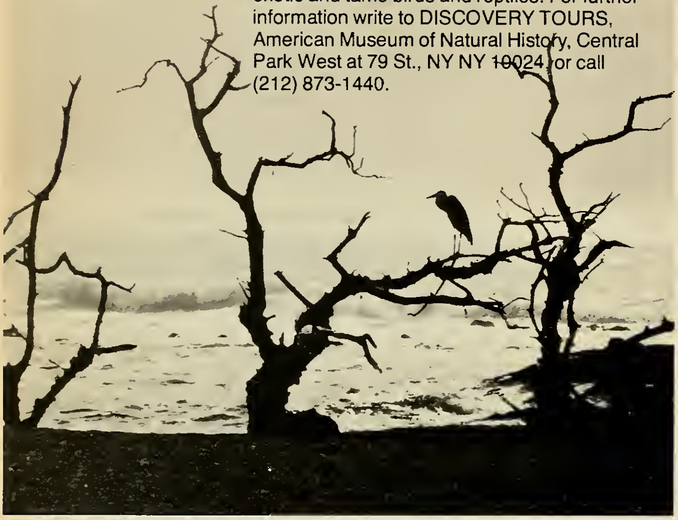

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# Far-out Erupting Volcanoes

*How a discovery about Io, one of Jupiter's moons, was made*

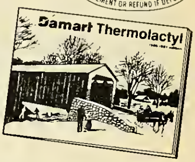
**by Stephen P. Maran**

Of all the fantastic phenomena observed by the immensely successful *Voyager* mission to the planet Jupiter, none excites the imagination more than the discovery of erupting volcanoes on the Jovian moon Io (see "By Jove," *Natural History,* May 1980). Indeed, this finding so intrigued various magazine editors that last January, the same *Voyager* photograph of a volcanic eruption was run on the covers of *Smithsonian, National Geographic,* and *Scientific American.*

Although there is evidence of past volcanic processes on our moon and on the planet Mercury, and giant volcanic mountains have been photographed on Mars and have been inferred, by means of cloud-penetrating radar, to exist on Venus, volcanism is most likely dead on all of those objects. Even if this judgment is found to be premature—like the opinions of those Washington State residents who thought Mount St. Helens was permanently dormant—the fact remains that, before the *Voyager* mission, erupting volcanoes had been seen only on the earth. Before *Voyager,* we also had no direct evidence of the processes at work in the interiors of celestial bodies beyond our moon. Now the *Voyager* photos and instrumental readings tell us about the tiny world of Io, suggesting the presence there of deep deposits of molten material, perhaps sulfur and its compounds, or earthlike magma impregnated with an unusual amount of sulfur.

The official report of the discovery of Io's eruptions, a three-paragraph paper in *Science* magazine, was signed simply "L.A. Morabito, S.P. Synnott, P.N. Kupferman, and Stewart A. Collins." With the exception of Collins, the authors were not members of the NASA imaging team, the scientific group selected for research with the *Voyager* cameras. They were, instead, members of the support staff at the Jet Propulsion Laboratory (JPL) in Pasadena, assigned to the extensive preparatory work of the space mission. Thousands of engineers and scientists like them make up the behind-the-scenes staff of the space program, people who do the lion's share of work needed to ensure that all will go well at the moment of truth when the spacecraft encounters another world.

Linda Morabito, who spotted the first eruption on Io while working as an engineer with the *Voyager* Navigation Team, is credited with developing computer programs to analyze star positions and keep track of the spacecraft trajectory. Steve Synnott, of the same team, helped develop ways to process images and analyze orbits. Stewart "Andy" Collins is a supervisor in the photo-science group, the technical staff for optical and photographic matters. And Peter Kupferman, also a member of the latter group, was its liaison representative



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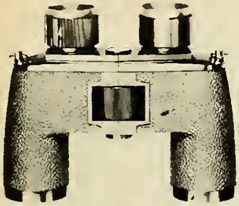

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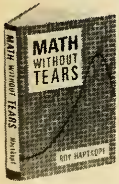

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to the Navigation Team. He computed the exposure times for the *Voyager* photographs and helped calibrate the cameras. With the exception of Collins, the four authors could hardly have anticipated that one day they would publish their own major discovery made with *Voyager.*

Any two eyewitnesses to history, like any two witnesses to an automobile accident or a bank robbery, will tell slightly different stories. The following account, based primarily on Kupferman's recollections as told to me many months after the fact, is a subjective impression of how events unfolded and how the discovery of Io's eruptions was confirmed.

Like the mariners of old, the *Voyager* navigators use the positions of stars as seen from their "ship," in this case a spacecraft, to determine where they are and how fast they are going. These stars—in the instance of *Voyager*—are 8th or 9th magnitude in brightness, too faint to be seen with the naked eye but observable with the spacecraft cameras. Photographs properly exposed to gain information about Jupiter and its moons are referred to as "science frames." Pictures taken with the same cameras but using longer exposures in order to feature background stars beyond the planet are called "navigation frames."

A one-second exposure shows the 8th magnitude stars quite well but leaves the fainter 9th magnitude stars rather weakly imaged. However, longer exposures cause the star images to trail into short arcs because the spacecraft moves during the interval of the exposure. Blurring is absent in the beautiful science frames of Jupiter and its moons sent back by *Voyager* because those objects are so bright that the exposure times are generally less than one second.

Navigation frames were generally taken at large distances from the Jupiter moons system as *Voyager 1* approached its March 5, 1979, rendezvous with the giant planet and, later, as it proceeded toward Saturn. Prime flyby time—when the spacecraft was nearest Jupiter and its moons and when the moons thus appeared largest through the camera lenses—was devoted to science frames. Thus, the science team generally ignored the navigation frames, which were presumed to be overexposed and to contain only small and therefore not sharply resolved images of the moons.

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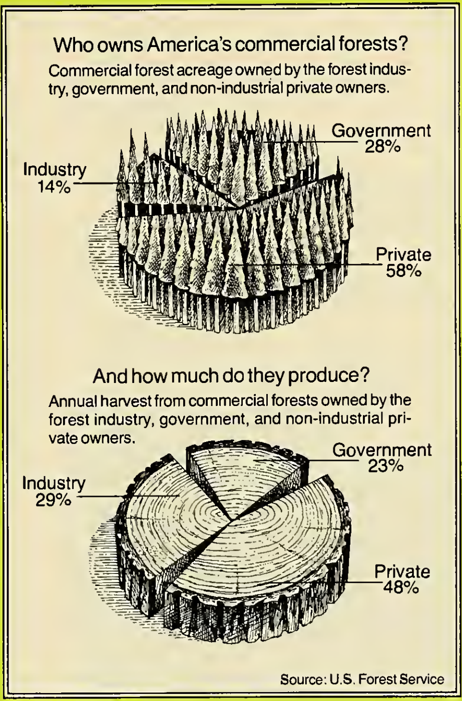

Who owns America's commercial forests?

Commercial forest acreage owned by the forest industry, government, and non-industrial private owners.

And how much do they produce?

Annual harvest from commercial forests owned by the forest industry, government, and non-industrial private owners.

Source: U.S. Forest Service

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## What is a commercial forest?

*Commercial forest,* as defined by the U.S. Forest Service, is *all* forestland — whether owned by individuals, government or the forest industry — that is capable of, and potentially available for, growing repeated crops of trees for harvest. It includes land in National Forests but not in National Parks or Wilderness areas.

On all commercial forestland, tree growth per acre averages only 61% of potential, which is not good enough. The greatest room for improvement, however, is in National Forests, where trees now grow at only 48% of potential.

Yet as the industry has shown, the growth cycle can be speeded by applying such techniques as: encouraging natural regrowth, planting superior seeds and seedlings, fertilizing, thinning and protecting trees from disease, insects and fire.

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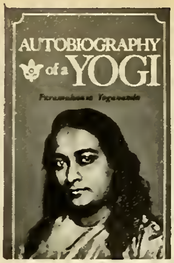

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9, Morabito was examining the electronically displayed image of a navigation frame of Io and two stars. To "bring up" the weakly exposed image of the fainter star, she used a contrast-enhancement feature at her computer console. On the enhanced photograph, she discovered a thin crescent just outside the limb of Io. Io itself was a crescent moon in this frame, taken at a distance of 2,800,000 miles as *Voyager 1* looked back while proceeding toward Saturn. We now know that the small, thin crescent was a cloud of erupted solid particles and gas, seen from the side. No such ghostly arc had been observed before.

Kupferman got a message that morning to go see Morabito. Exhausted from helping the science team day and night during the Jupiter flyby and its immediate aftermath, he at first ignored the message. Later in the day, while a press conference on flyby results was under way, he headed for Morabito's office where she pointed out the arc on her screen. It showed on only one photograph. Was it real or an optical effect? Perhaps scattered light in the *Voyager* instrument or glare or some strange multiple reflection? If another Jovian moon were located behind Io as seen from *Voyager*, it too would have had a crescent appearance. Was this the explanation of the crescent? In fact, if Io itself had a moon, the subordinate moon also would have had an illuminated crescent shape in the reflected light of the sun. Morabito and Synnott checked on the other known Jovian moons but soon found that there was no chance that any of them had been in the background when the Io photograph was made.

Another remarkable feature on the screen, ignored at the time but later to attract much attention, was a bright spot on the dark part of Io, just inside (but not within) the solar-illuminated crescent of the moon itself.

After looking at Morabito's photograph, Kupferman got Collins, the photo-science supervisor, on the phone and told him with some urgency, "There's something you ought to see on one of the navigation frames." When Collins arrived, he took one look and said, "I bet you that's a volcanic eruption." The possibility may have been discussed earlier, and indeed a trio of scientists from the University of California, Santa Barbara, and the NASA-Ames Research Center actually had predicted active volcanism

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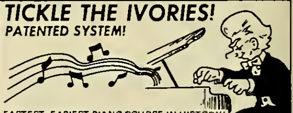

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on Io. But no one seriously expected to see an eruption in progress. Terrestrial volcanoes do not produce plumes two hundred miles high, as we now observe on Io.

We also now know that the temporarily ignored bright spot within Io's crescent was a second eruption emanating from a volcano on the dark part of Io. The plume extended up so high that it caught the rays of the sun like a high cloud overhead just after sunset. At the time, however, the navigators were concentrating on determining whether a volcanic eruption could truly account for Morabito's arc off the limb of Io. The fact remained that they had only one photograph of it. Based on the position of the arc off the limb, and assuming that it was right at the limb rather than well beyond it along the line of sight, Morabito and Kupferman estimated the location of the spot on Io beneath the arc. Would this location correspond to any interesting surface feature noted in the properly exposed science frames?

Kupferman had previously worked at a solar observatory and still had the program for his pocket computer that was used to relate sunspot positions on an observatory TV screen to solar latitudes and longitudes. This program was adapted to the problem at hand, and by the end of the day, the calculation was done. In another room at JPL, a cartographer was still at work, airbrushing details onto a new Mercator projection map of Io, based on the close-encounter science frames. The artist stepped back from her drawing board and the excited pair checked their computed coordinates against the map. One end of the arc was right over a heart-shaped surface feature on the map. Scientists earlier had speculated that this feature might be a volcano. Now the navigators knew that it must be even more than that—it was an *active* volcano.

At this point, although still dependent on the single navigation frame, the discovery seemed solid enough to report. Most of the science team had left town for a long weekend at home with their families in college towns around the country. The leaders of the team were reached by phone over the weekend and one member, Joseph Veverka of Cornell University, prepared to reexamine all of the science frames of Io with enhanced contrast.

By Monday morning, several of the scientists had gathered at the lab with Veverka when Kupferman strolled in at about nine o'clock. He remembers that as he entered he heard "cheers and amazed cries." Looking across at a TV screen, he saw a beautiful volcanic plume on one of the enhanced science frames. The navigators' discovery had been confirmed.

In all, eight erupting volcanoes were found on Io by *Voyager 1*. When *Voyager 2* came by Io eighteen weeks later, seven were still erupting. Some physicists now speculate that the eruptions are of such magnitude that the physical cause, assumed by the three scientists previously referred to who had predicted the volcanism, namely, tides raised inside Io by the powerful gravity of Jupiter, is insufficient to account for them. Instead, the physicists hypothesize that powerful electrical forces are at work, enhancing the heating of Io's interior and generating the molten stuff. Other *Voyager* findings show that some of the gas erupted from Io becomes electrified and streams down lines of magnetic force onto the polar regions of Jupiter, where it causes brilliant auroras.

*Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.*

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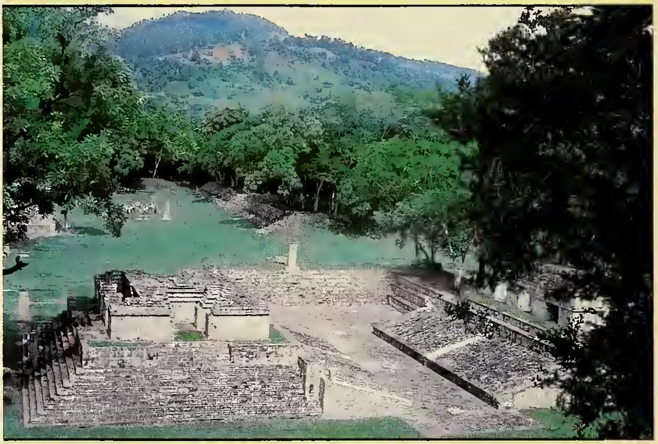

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# Additional Reading

**Pygmy Chimpanzees** (p. 32)

D. Freeman's *The Great Apes* (New York: G.P. Putnam's Sons, 1979), a large, colorful summary of recent field studies for the nonspecialist, contains a short, illustrated account of pygmy chimpanzees. *The Apes,* by V. Reynolds (New York: E.P. Dutton, 1967), is a somewhat technical account of the history of research on living apes. J. MacKinnon's *The Ape Within Us* (New York: Holt, Rinehardt and Winston, 1978), a comprehensive account of the natural history and evolution of the living apes, serves as the basis for prediction about humankind. "Pygmy Chimpanzees" by A. and N. Badrian (*Oryx,* vol. 5, no. 13, pp. 463–68), reports the results of a six-month behavioral study of these animals, conducted intermittently during 1974–75 in an equatorial rain forest in Zaire, and urges establishment of a chimpanzee reserve in Lomako Forest. "A Pilot Study on the Ecology of Pygmy Chimpanzees," by T. Kano, in *The Great Apes,* edited by D.A. Hamburg and E.R. McGown (Menlo Park: The Benjamin-Cummings Publishing Co., 1979), is an extensive study of the pygmy chimpanzee in its natural habitat.

**Pack Rat Fossils** (p. 40)

T.R. Van Devender's "Holocene Woodlands in the Southwestern Deserts" (*Science,* October 14, 1977, pp. 189–92), an account of twenty-nine radiocarbon-dated pack rat middens, documents the existence of woodland

**Asia** (p. 46)

Both the Koran and the Torah are important source material for further reading in Islam and Judaism. The Koran, the holy book of Islam and the true word of God as revealed by the Prophet Mohammed, is the ultimate legal and religious authority for Muslims. A.J. Arberry's *Koran Interpreted* (New York: Macmillan Publishing Company, 1964) is a modern translation of the Koran known for its literary qualities and respected by Muslims for its accurate rendition of Koranic style. The Torah, or strictly speaking the Pentateuch, comprises the first five books of the Bible—Genesis, Exodus, Leviticus, Numbers, and Deuteronomy.

*Sources of Indian Tradition* (1958), *Sources of Japanese Tradition* (1958), and *Sources of Chinese Tradition* (1960), were published by Columbia University Press, New York. For readers interested in learning more about India, China, and Japan, these two-volume works, edited by W. T. DeBary, offer excerpts from literary, political, and sociological works from classic times to the present.

*East Esia: Tradition and Transformation* by J.K. Fairbanks, E.O. Reischauer, and A.M. Craig, (Boston: Houghton Mifflin, 1977), provides an introduction to the history and civilizations of China, Japan, Vietnam, and Korea. The first half of the book traces the origin and development of East Asia's society and civilizations; the second half discusses the impact of

communities in the southwestern United States 10,000 years ago and hypothesizes that climate was affected by melting continental glaciers. In "Development of Vegetation and Climate in the Southwestern United States" (*Science*, May 18, 1979, pp. 701–10), T.R. Van Devender and W.G. Spaulding analyze pack rat middens, describe vegetational changes, and draw some conclusions about United States desert climates during the past 22,000 years. More theories about climate in the past can be found in *Pleistocene Extinctions: The Search for a Cause,* edited by P.S. Martin and H.E. Wright, Jr. (New Haven: Yale University Press, 1968).

*Katharine D'Agosta*

Western culture and technology.

A description of people who live by ancient traditions but have had to adapt to modern civilization can be found in D. Cole's *Nomads of the Nomads: The Al Murrah Bedouin of the Empty Quarter* (Arlington Heights: AHM Publishing Corp., 1975).

*The Malays: A Cultural History*, by R. Winstedt (Boston: Routledge and Kegan Paul, Ltd., 1961), gives information on the history, art, and culture of India and of the Far East, and will be of particular interest to students of Islam.

An illustrated work by R.A. Stein, *Tibetan Civilizations*, translated by J.E. Driver (Stanford: Stanford University Press, 1972) is an introduction to Tibet, its people, religion, and culture.

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# Celestial Events

by Thomas D. Nicholson

**The Moon** Watch for the harvest moon from September 23 to 25, and the hunter's moon on about the same dates in October. At both times the full, or nearly full, moon appears to fill the eastern sky with brilliance from sundown for three nights in succession. Moon phases in September are: last-quarter on the 1st, new moon on the 9th, first-quarter on the 17th, full on the 24th and last-quarter again on the 30th. The October new moon is on the 8th, first-quarter on the 16th, full moon on the 23rd, and last-quarter on the 30th.

**Stars and Planets** The bright planets are just about evenly divided between the evening and morning sky: two evening stars (Mercury and Mars), one morning star (Venus), and two planets (Jupiter and Saturn) shifting from the evening to the morning sky. But only one, Venus, can be readily seen. It puts on a very good show as a morning star, rising between 2:30 and 3:30 A.M. daylight time, high and brilliant in the southeast at dawn, and fading in late twilight.

During September, the sun moves about mid-month from the constellation Leo into Virgo and remains there until the end of October. Mercury keeps pace with the sun through the same constellations, while Venus moves out of Gemini in early September, spends most of the month in Cancer, and moves into Leo for late September and October. Mars moves from Virgo into Libra in mid-September; Jupiter from Leo into Virgo; Saturn is in Virgo; Uranus in Libra; Neptune in Ophiucus; and Pluto in Bootes.

September 1: The star near the moon this morning is Aldebaran, in Taurus.

September 5: Venus stands just below the "nether" tip of the moon at dawn this morning. Watch from moonrise (about 3:00 A.M. daylight time) on to see the moon approach and pass the planet.

September 13: Jupiter is in conjunction with the sun and becomes a morning star. You may still be able to see Mars as an evening star to the right and below the crescent moon tonight.

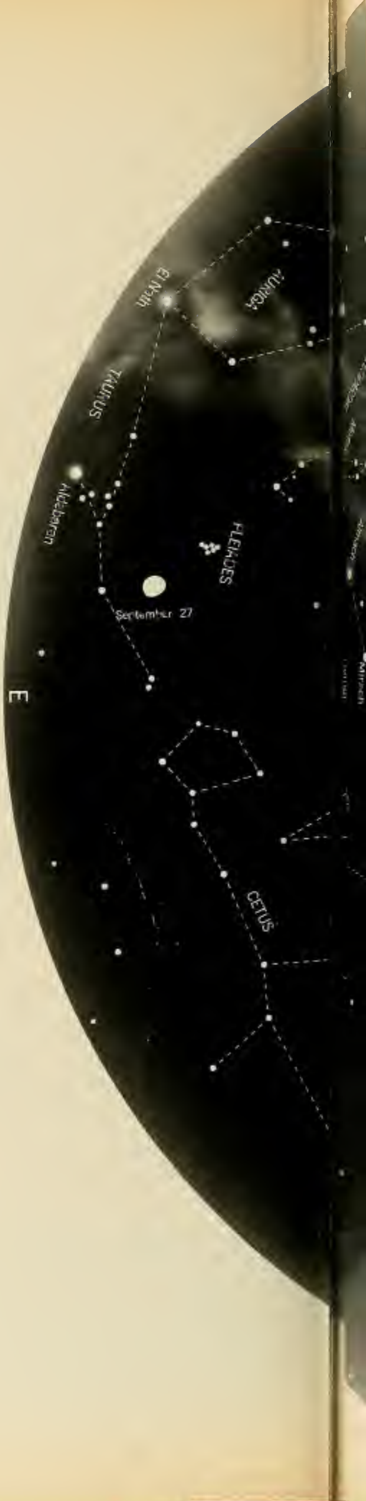
September 22: An auspicious day! The sun arrives on the equatorial plane today, at the point in the constellation Virgo known as the autumnal equinox. That marks the end of summer and the beginning of autumn in the Northern Hemisphere. The date of the "effective" equinox, however, when day and night are equal (and the sun spends half its time above the horizon and half below) is September 26.

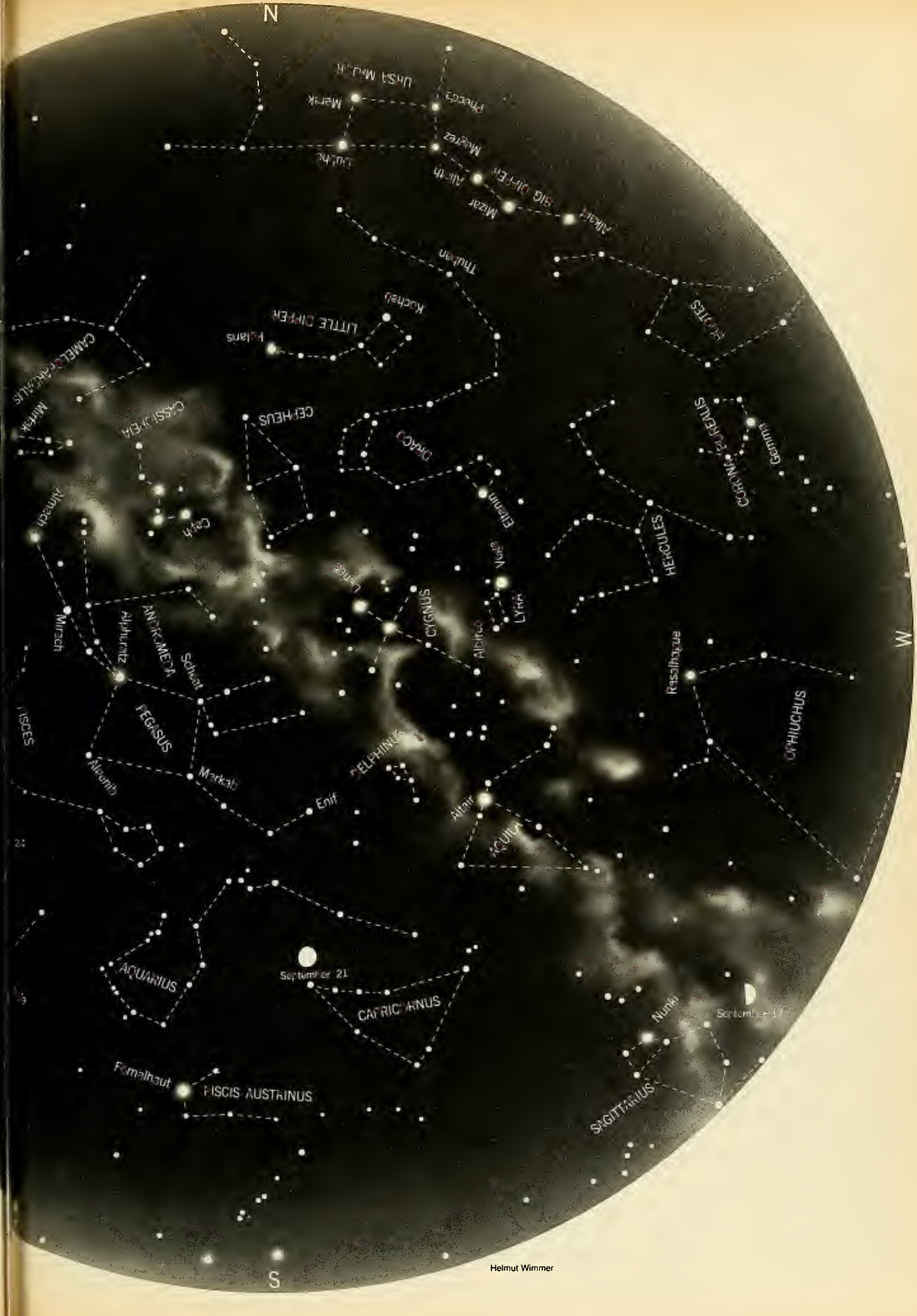
September 24: Look for exceptionally strong tides tonight, as perigee occurs just 15 hours after the harvest full moon.

September 28–29: The star close to the moon tonight and tomorrow morning from moonrise (about 10:00 P.M. daylight time) on is Aldebaran.

October 4–5: It will be worth getting up early on both mornings to see Venus, Regulus, and the moon in the east. Venus passes the star during the day on the 4th, and the crescent moon passes both star and Venus before they rise on the 5th.

**Evening Star Map** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those in the sky. When you turn to face in other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match the stars in the sky with those on the lower half of the map. The map represents the sky at about 11 to 12 P.M. on September 1; 10 to 11 P.M. on September 15; 9 to 10 P.M. on September 30; and 8 to 9 P.M. on October 15. It shows only planets and moon phases above the horizon at those times.

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# A Squirrel in Every Pot

*A dish that emerged from the cabins of pioneer America has undergone a drastic change*

**by Raymond Sokolov**

When Dr. Creed Haskins and several of his friends returned from a day's hunting in the woods of Brunswick County, Virginia, in 1828 or thereabouts, they found their loyal black retainer Uncle Jimmy Matthews stirring a stew he had concocted in their absence. They ate it, hesitantly at first, then smacked their lips and called for more. By then, it did not dampen their appetites to learn that Matthews's thick and flavorful ragout was made from nothing more than butter, onions, stale bread, seasoning, and a passel of squirrels the slave had shot that morning.

This, at any rate, is the legend of the origin of Brunswick stew, the most famous dish to emerge from the campfires and cabins of pioneer America. Brunswick stew is still prepared in big caldrons at church suppers, volunteer firehouse fund-raisers, and all manner of communal celebrations throughout the Southeast. But it is virtually never cooked according to the original recipe. Dr. Haskins began the eroding of his servant's invention when he added some brandy or Madeira to "give the stew a flavor." Then, probably about the turn of the century, well-meaning cooks domesticated Matthews's squirrel *pot-au-feu* still further by throwing in vegetables.

In his classic statement on the subject, made in 1907, Meade Haskins, a descendant of Uncle Jimmy's master, fulminated against this fancification: "Vegetables are not in the original Brunswick stew. Those who prefer vegetables add them after the stew is done, in their plates."

This Haskins also set down the pure and authentic recipe he had received from his father, Dr. A.B. Haskins:

> Parboil squirrels until they are stiff (half done), cut small pieces of bacon (middling), one for each squirrel; one small onion to each squirrel (if large, one to two squirrels), chopped up. Put in bacon and onions first to boil, while the squirrels are being cut up for the pot. Boil the above till half done, then put in butter to taste; then stale loaf bread, crumbled up. Cook then till it bubbles, then add pepper and salt to taste. Cook this until it bubbles and bubbles burst off. Time for stew to cook is four hours with steady heat.

Although this text is not as clear as one might like, it offers adequate proof of what Brunswick stew once was, before modern innovators turned it into a veritable succotash of corn and tomatoes and beans and what not (see recipe below). But vegetables are hardly the principal infraction against authenticity currently practiced in Brunswick County and almost everywhere else. Modern Brunswick-stew makers have not only added vegetables; they have eliminated the squirrel.

*Large kettles hold burgoo, a stewlike mixture of meat and vegetables.*

Now I am not here to claim that a Brunswick stew made with squirrel is superior in any way to Brunswick stew made with chicken. And I certainly have no wish to join battle with those who may have had the opportunity to become fans of variant recipes based on opossum, muskrat, or raccoon. I would merely like to have the chance to taste the original dish. But I doubt I will, unless some hunter favors me with a brace of squirrels. They would have to be wild, woodland squirrels, of course, not urban squirrels that have fed on garbage.

This requirement, which I insist on to preserve my health, did not concern pioneer Virginians, who enjoyed a pristine, rural life style and woods abounding in fat, nut-fed squirrels. Today, however, most of us live in town and our only regular access to traditional game meats is through commercial butchers and restaurants. The law forbids the sale of uninspected game animals that have been shot in the wild. The venison we eat in a restaurant has been produced, like beef or lamb, on a ranch, and lacks the special taste of wild meat. And since no one, so far as I know, has started raising squirrels commercially, that means that even in Brunswick County, Virginia, you will not find traditional Brunswick stew, except perhaps in the home of some backwoodsman with an eccentric passion for gastronomic folklore.

"I couldn't put squirrel in my Brunswick stew even if I wanted to," says Larry of Larry's Lunch, the only restaurant in Lawrenceville, Virginia, the Brunswick County seat. He doesn't even list the dish on his menu, but if you ask him, he will sell you a thick farrago of chicken (cooked until it has fallen apart), lima beans, to-

Photographs by Adalaida de Menil

*A crowd of Kentucky picnickers feast on burgoo and barbecued mutton.*

matoes, and potatoes that turns out to be a peppery, sinus-clearing soup of a high order. Larry claims this is a definite improvement over the squirrel-based Brunswick stew he used to eat in his younger days on the farm.

Maybe so, but I wouldn't mind seeing for myself if truly authentic Brunswick stew is worth reviving. I apologize to those who find the notion of eating cute little furry squirrels positively repugnant. And I suspect that this sentimental revulsion is part of the reason that Americans from one end of Appalachia to the other have eliminated squirrel from their hunter's stews. The same thing has occurred in the case of burgoo, which is a stewlike potpourri of meat and vegetables invariably supplied at political rallies and other outdoor gatherings in Kentucky, as well as southern Indiana and Illinois. Some people think that burgoo began during the Civil War, when a soldier with a speech impediment created a stew from blackbirds in a 500-gallon copper caldron normally used for making gunpowder. The soldier meant to call his creation "bird stew," but he actually said "burgoo."

Others have looked for a French etymology. But "burgoo" was undoubtedly in use as early as 1740 to describe a porridge eaten by British sailors. The nautical English novelist Frederick Marryat has a sailor in his book *Peter Simple* (1834) say: "Mark my words, you burgoo-eating . . . trowsers-scrubbing son of a bitch!"

It is not hard to imagine how the British fleet hit upon burgoo as a name for oatmeal. Some sailors on shore leave in a Levantine port must have made contact with the wheat pilaf called burghul (or bulgur) and transferred the name, with a slightly distorted pronunciation, to their oatmeal. This Turkish burghul became Peter Simple's burgoo. And in America, the exotic and faintly pejorative word quite probably attached itself to a similarly mushy mess of pottage concocted ad libitum from available vegetables and meats, one of which was, in Daniel Boone's Kentucky, squirrel.

The modern history of Kentucky burgoo begins with a certain James T. Looney, a retired railroad engineer. At his mother's bidding, Looney gave up the perils of railroading for a grocer's career in Lexington and then turned his hand to burgoo. For forty years he catered burgoo to crowds as large as 10,000. Looney was Kentucky's "burgoo king" and so renowned in the Bluegrass State that a thoroughbred colt was named after him. Burgoo King, the horse, won the Kentucky Derby in 1932.

Success did not spoil Jim Looney. All his long life, he upheld the highest standards of burgoo cookery. He took the meats out of his giant kettles (one of them said to have been used for making saltpeter during the Revolutionary War) midway through the 24-hour cooking process and chopped them up before returning them to the kettles. "You find no strings in my burgoo," he said.

You would find no squirrel either, according to his recipe for burgoo for 5,000 people recently printed in the *Louisville Courier-Journal*:

> 800 pounds beef, 200 pounds fowl, 168 gallons canned tomatoes, 350 pounds cabbage, 6 bushels onions, 85 gallons tomato purée, 24 gallons carrots, 36 gallons canned corn, 1,800 pounds potatoes, 2 pounds red pepper, ½ pound black pepper, 20 pounds salt, 8 ounces Angostura bitters, 1 pint Worcestershire sauce, ½ pound curry powder, 3 quarts tomato catsup, and 2 quarts sherry.

Today, fiery hot burgoo is available at simple restaurants in Louisville and throughout the Ohio River Valley to the west, always without squirrel or other sylvan beasties. Perhaps this makes no difference. Modern, lunch counter burgoo is a fine thing, although it owes most of its character to its red pepper. I cannot help thinking, however, that a little gaminess would restore this country dish to a vanished glory.

I came to this conviction in Owensboro, Kentucky, a middling metropolis west of Louisville on the Ohio. Owensboro is the barbecue mutton capital of the world. Every May, carloads of ewes are cooked over pits of hickory at the Owensboro International Barbecue Festival. During the average summer, local Catholic parishes run through 800,000 pounds of mutton at fund-raising barbecues, where exclusively male chefs cook the meat over an open flame for eighteen hours or so. No one knows why the people of Owensboro have chosen mutton as their meat of preference over equally traditional beef, pork, venison, bear, elk, and buffalo. The proprietor of Hardman's on East 4th Street, one of sixteen barbecue places in a town of 50,000, says: "Mutton stands up to flame better. It has a hard skin. Lamb falls apart."

Mutton also tastes different from lamb. It has a feisty tang to it, a high, almost gamy flavor that can hold its own even against the heady amounts of red pepper commonly added to burgoo. As I sat in the Hardman's dining room, a tiny area with a few tables next to a cold-storage locker containing two dressed ewes, I ate a bowl of superbly muttony burgoo and speculated that when the venison and buffalo became scarce at the end of the last century, Owensboro barbecue chefs, who were even then attracting trainloads of hungry tourists each spring and summer, turned to mutton as the best commercially available substitute for game meats at their famous cookouts.

Once they had established mutton as the main meat for barbecue, it was the natural thing to use some of it for burgoo. Mutton could give burgoo the same oomph that squirrel and opossum had formerly provided. There is no proving this, but if you want to taste a very reasonable facsimile of an authentic American hunter's stew without bagging a squirrel, stop over in Owensboro some time for mutton burgoo.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

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### Cissy's Burgoo

(Courtesy of the *Louisville Courier-Journal*)

| | |
|---|---|
| 2 | pounds pork shank |
| 2 | pounds veal shank |
| 2 | pounds beef shank |
| 2 | pounds breast of lamb |
| 1 | 4-pound hen |
| 8 | quarts water |
| 1½ | pounds Irish potatoes |
| 1½ | pounds onions |
| 1 | bunch carrots, scraped and chopped |
| 2 | green peppers, seeded and chopped |
| 2 | cups chopped cabbage |
| 1 | quart tomato purée |
| 2 | cups whole corn, canned or fresh |
| 2 | pods red pepper |
| 2 | cups diced okra |
| 2 | cups lima beans |
| 1 | cup diced celery |
| | Salt, Cayenne, Tabasco, A-1 Sauce, Worcestershire to taste |
| | Chopped parsley |

Put all the meat into cold water and bring slowly to a boil. Simmer until meat falls from the bones. Remove and chop up meat, discarding bones. Pare and dice potatoes and onions. Return meat to stock and add all vegetables (except parsley). Allow to simmer until thick. Burgoo should be very thick but still soupy. Season as you go along, but not too much, until it is almost done. Stir frequently with a long-handled wooden spoon during the early stages and almost constantly after it thickens. Add chopped parsley at the end.

This is made in a four-gallon kettle and cooked approximately ten hours. The time can be broken up by cooking the meat the first day and adding the vegetables the second day.

Yield: 60 servings

### Brunswick Stew—1975

(A synthesis of several traditional recipes, as compiled by Gay Neale in *Brunswick County, Virginia, 1720–1975.*)

| | |
|---|---|
| 1 | 3-pound chicken |
| 2 | pieces of celery |
| 1 | small onion |

Add a quart of water and simmer until meat is tender. Cool. Discard celery. Remove meat from bones and shred into small pieces. Then add:

| | |
|---|---|
| ¼ | stick butter |
| 1 | cup chopped onion |
| 1 | quart butterbeans (canned or frozen are good; fresh is better) |
| 1 | quart corn (whole kernel canned or frozen or fresh) |
| 2 | quarts tomatoes |
| 3 | medium potatoes, diced |

Continue cooking over mediu heat, adding water if necessary an stirring occasionally until separat identity of ingredients is no longe apparent—at least five hours. Seaso with salt, red pepper, and more blac pepper than seems sensible—at leas 2 teaspoons. Thicken with bread crumbs, crackers, or biscuit crumbs

Yield: 4-6 servings

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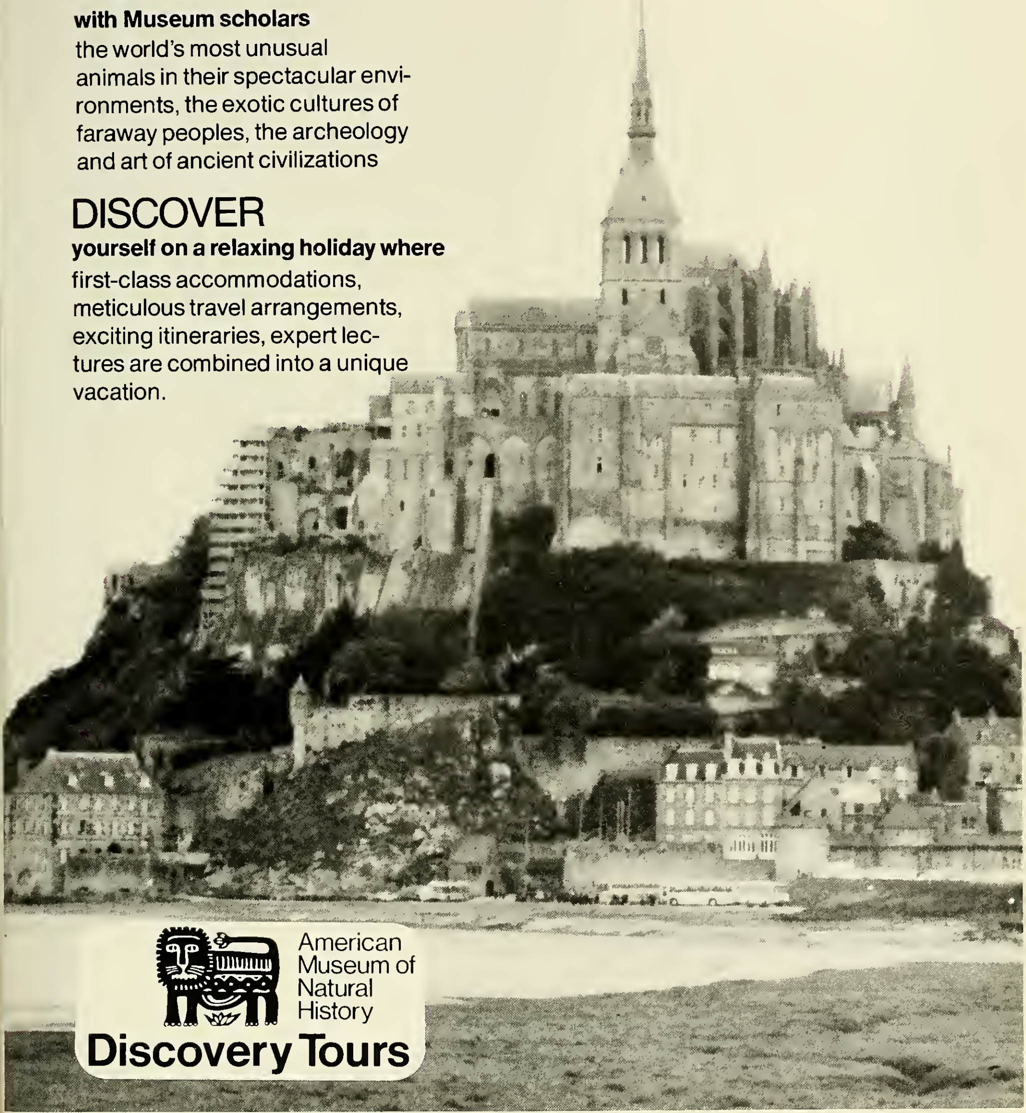

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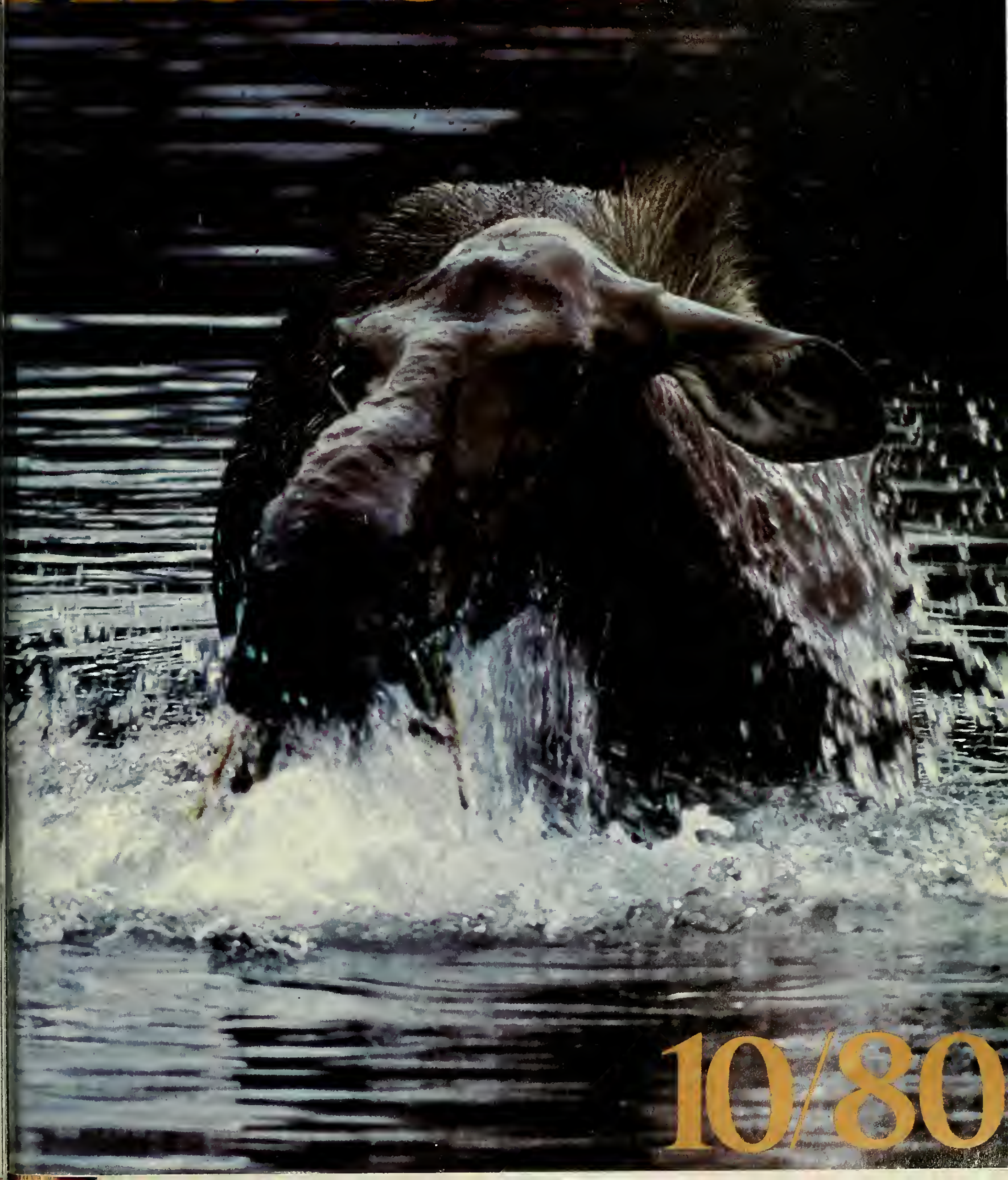

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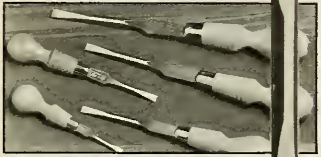

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# Authors

Since 1966, **Gordon C. Haber** has been conducting an intensive field study of wolves and grizzly bears and their ungulate prey—moose, mountain sheep, and caribou—in the Denali (Mount McKinley) region of Alaska. With more than 10,000 hours of observations under his belt, he is planning to continue the study. Haber received his Ph.D. in zoology from the University of British Columbia, and formerly taught biology at Anchorage Community College. He does consulting work on ecological matters and is also the owner and operator of a wilderness lodge and guide service in the Brooks Range of northwest Alaska.

Since Erbaba, the site of their archeological excavations, is in an opium-producing region of Turkey, **Jacques Bordaz** and **Louise Alpers Bordaz** have observed the many uses to which local villagers put the opium poppy plant and the effects of government regulation on opium poppy cultivation. The authors' archeological research concerns the development of animal and plant domestication and sedentism. In addition, they study traditional crafts and life styles in contemporary Turkey for the light they may shed on archeological interpretation. In 1971 they produced a short film, *Stone Knapping in Modern Turkey.* Jacques Bordaz is an associate professor of anthropology at the University of Pennsylvania; Louise Alpers Bordaz is an assistant professor in Columbia University's Department of Art History and Archaeology.

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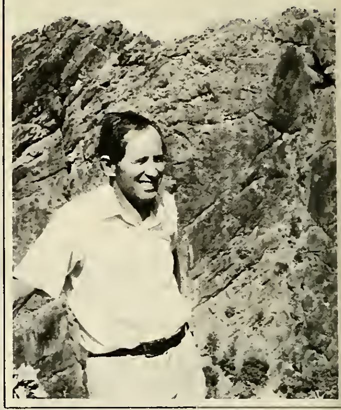

**James H. Shaw** has done fieldwork on wood ducks in Connecticut, red wolves in Texas, coyotes in Oklahoma, and giant anteaters in Brazil. An associate professor of wildlife ecology at Oklahoma State University, Shaw wrote about his work on red wolves in the December 1977 issue of *Natural History* ("The Wolf That Lost Its Genes"). He reports, "Tracy Carter and I met at the American Society of Mammalogists meeting in 1975, and I visited her while she was a Peace Corps volunteer in Brazil. We became interested in anteaters and developed field studies together. Our relationship is not exclusively professional, however, as we were married on December 28, 1977."

**Tracy S. Carter** received her Ph.D. in zoology from Michigan State University. In addition to serving as a Peace Corps volunteer in Brazil, she was an expedition leader on a project that studied the burrow characteristics and food habits of armadillos. Carter and Shaw plan to do research on the carnivores of the Brazilian National Park, Serra da Canastra.

**Phillip E. Playford** first became interested in stromatolites when he visited Hamelin Pool, Western Australia, as a member of an oil exploration team, and found these strange algal structures growing there. He has since carried out extensive research on these "living fossils," as well as on dead stromatolites in ancient reefs. Playford, who holds a B.Sc. in geology from the University of Western Australia and a Ph.D. from Stanford University, which he attended as a Fulbright scholar, is currently deputy director of the Geological Survey of Western Australia. In 1978 he toured the United States and Canada as distinguished lecturer of the American Association of Petroleum Geologists.

In 1969 **Margaret B. Blackman's** dissertation adviser handed her a photograph of the interior of a Haida Indian chief's house on America's Northwest coast, with the comment: "Why don't you see what you can do with this." After a search that led from the Queen Charlotte Islands through the photo archives of North America to London, Blackman completed her doctoral dissertation on recent Haida cultural history as seen through early photographs. She is now associate professor of anthropology at the State University of New York College at Brockport. Summer finds her in British Columbia, working on various field and archival research projects.

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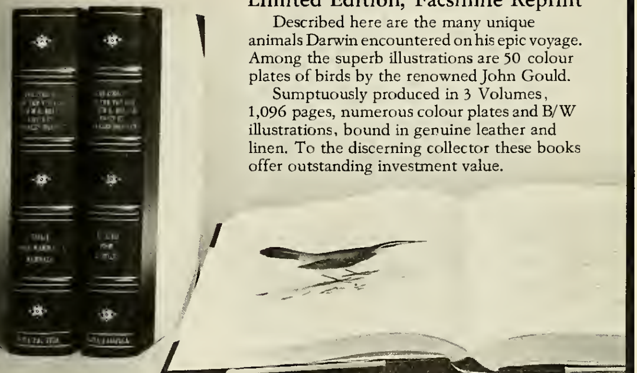

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# Hopeful Monsters

*Teratology, the study of deformed births, helps explain normal growth.*

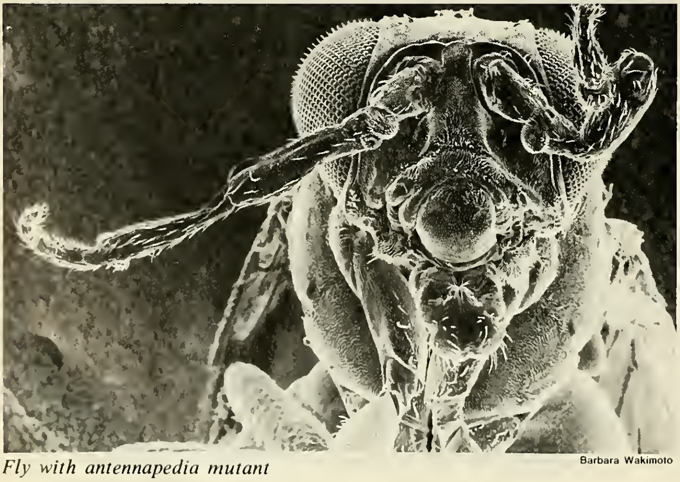
**by Stephen Jay Gould**

My grandfather, who taught me to play poker and watched the Friday night fights with me every week, once took me to one of the cruelest, yet most fascinating spectacles of decades now thankfully past—the rows of malformed people forced (by an absence of other opportunities) to display themselves to a gawking public at the Ringling Brothers sideshow.

The genteel and legitimate counterpart to such public cruelty is the vast scientific literature on deformed births—a subject dignified with its own formal name as teratology, literally, the study of monsters. Although scientists are as subject as all people to the mixture of awe, horror, and curiosity that draws people to sideshows, teratology has an important rationale beyond primal fascination.

The laws of normal growth are best formulated and understood when the causes of their exceptions can be established. The experimental method itself, a touchstone of scientific procedure, rests upon the notion that induced and controlled departures from the ordinary can lay bare the laws of order. Congenitally malformed bodies are nature's experiments, uncontrolled by intentional human art to be sure, but sources of insight nonetheless.

The early teratologists sought to understand malformations by classifying them. In the decades before Darwin, French medical anatomists developed three categories: missing parts (*monstres par défaut*), extra parts (*monstres par excès*), and normal parts in the wrong places. The folklore of monsters had long recognized the last category in tales of anthropophagi, maneaters with eyes in their shoulders and a mouth on their breast. Shakespeare alluded both to them and to some related colleagues in *Othello* when he spoke of "The Anthropophagi and men whose heads/Do grow beneath their shoulders."



*Fly with antennapedia mutant*

Barbara Wakimoto

But a classification is no more than a set of convenient pigeonholes until the causes of ordering can be specified. And here nineteenth-century teratology got becalmed in its own ignorance of heredity. The establishment of genetics in our century revived a waning interest in teratology, as early Mendelians discovered the mutational basis of several common deformities.

Geneticists had particular success with one common category in the old classification—normal parts in the wrong places. They studied their favorite animal, the fruit fly, *Drosophila melanogaster*, and found a variety of bizarre transpositions. In the first of two famous examples, the halteres (organs of balance) are transformed into wings, restoring to the aberrant fly its ancestral complement of four (normal flies, as members of the order Diptera, have two wings). In the second, legs or parts of legs replace a variety of structures in the head—antennae and parts of the mouth in particular. Mutations of this sort are called homeotic.

Not all misplacements of parts represent homeosis, and this restriction is a key to the evolutionary message I shall draw further on. William Bateson, who later invented the term ge-

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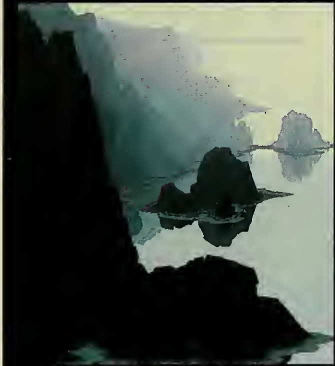
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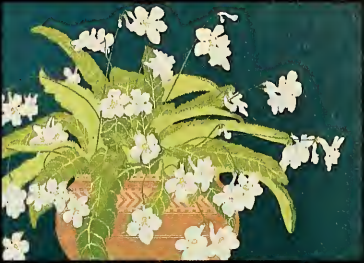
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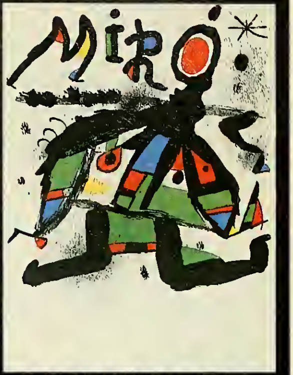

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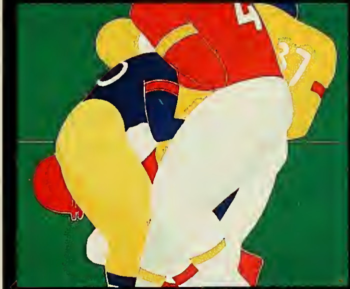
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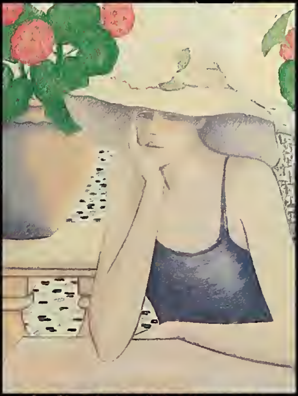
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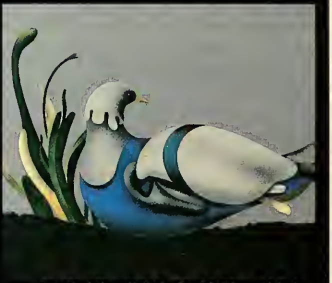
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netics, defined as "homeotic" only those parts that replace an organ having the same developmental or evolutionary origin (the word comes from a Greek root for "similar"). Thus, halteres are the evolutionary descendants of wings, while insect antennae, mouthparts, and legs all differentiate from similar precursors in the embryonic segments, and all presumably evolved from an ancestor with a pair of simple and similar appendages on each adult body segment. We might refer to homeosis if a human developed a second pair of arms where his legs should be, but an extra pair of arms on the chest would not qualify.

Homeotic mutants are found on all four pairs of chromosomes in *D. melanogaster*. A recent review by W.J. Ouweneel (*Advances in Genetics*, vol. 18, 1976) includes a list that runs to three full pages. But the two most famous, best studied, and elaborate sets of homeotic mutations both reside on the right arm of the third chromosome.

The first set, called the bithorax complex and abbreviated BX-C, regulates the normal development and differentiation of the fly's posterior body segments. The larval fly is already divided into a series of segments, initially quite similar, that will differentiate into specialized adult structures. The first five larval segments build the adult head (the first forms anterior parts of the head; the second, the eyes and antennae; and the third through fifth, the various parts of the mouth). The next three segments, $T_1$, $T_2$, and $T_3$, form the thorax. Each will bear a pair of legs in the adult, building the normal insect complement of six. The single pair of wings will differentiate in $T_2$.

The next eight segments ($A_1$ through $A_8$) form the adult's abdomen, while the final, or caudal, segment ($A_9$ and $A_{10}$) will build the adult's posterior end. If all the genes of BX-C are deleted from the third chromosome, all larval segments behind the second thoracic ($T_2$) fail to differentiate along their normal route and seem to become second thoracic segments themselves. Thus, the presence of normal BX-C genes appears to be a precondition for the ordinary development of all segments behind the second thoracic. If the adult survived, it would be a wonder to behold, with (presumably) a pair of legs on each of its numerous posterior segments. But this deletion is, in geneticist's jargon, "lethal," and the fly dies while still a larva. We know that the posterior segments of such aberrant flies are slated to develop as second thoracics because incipient differentiation within the larval segments serves as a sure guide to their later fate. (*Drosophila* geneticists, after seventy years of practice, have developed a remarkable bag of tricks for recognizing [or inducing] mutations, combining them, and fostering larger changes in the structure of chromosomes. Flies with small missing parts [deletions] of various chromosomes arise now and again, and these are avidly sought and propagated for their evident value in assessing the causes of normal development by charting malformations that arise when genes are missing.)

The bithorax complex consists of at least eight genes, all located in sequence right next to each other (see review in *Nature*, 1978, p. 565, by E.B. Lewis). Edward B. Lewis, the distinguished geneticist from the California Institute of Technology who has spent twenty years probing the complexities of BX-C, believes that these eight genes arose as repetitions of a single ancestral gene and then evolved in different directions. (I must defer the fascinating subject of gene duplication and its evolutionary significance to a later column.) Just as the entire deletion of BX-C produces the striking homeotic effect of converting all posterior segments to second thoracics, several mutations in the eight genes produce homeotic results as well. The most famous mutation, called bithorax and commandeered as a name for the entire complex, converts the third thoracic segment into a second thoracic. Thus, the adult fly develops with two second thoracics and two pairs of wings, instead of one pair and a pair of halteres behind. (It is misleading to state that halteres "turn into" wings. Rather, the entire segment normally destined to be a third thoracic, and to produce halteres, develops as a second thoracic and builds wings.) In another mutation, called bithoraxoid, the first abdominal segment develops as a third thoracic, builds a pair of legs, and yields a fly with more than the usual insect number of six.

Lewis has proposed an interesting hypothesis for the normal action of BX-C genes. He believes that they are initially repressed (turned off) in the larval fly. As the fly develops, BX-C genes are progressively derepressed (turned on). The BX-C genes act as regulators—that is, they do not build parts of the body themselves but are responsible for turning on the structural genes that do code for building blocks. Adult form reflects the amount of BX-C gene-product in an embryonic segment; the more BX-C, the more posterior in appearance the segment. Lewis then argues that BX-C genes are derepressed in sequence, from the anterior point of their action (the third thoracic segment) to the back end of the animal. When a BX-C gene turns on, its product accumulates in a given segment and, simultaneously, in all segments posterior to it. BX-C first turns on in the third thoracic, and its product accumulates in all segments from the third thoracic to the posterior end. The next BX-C gene turns on in the next posterior segment, the first abdominal, and its product accumulates in all segments from the first abdominal to the posterior end. The next gene turns on in the second abdominal, and so forth. Thus, a gradient of BX-C product forms, with lowest concentration in the second thoracic and increasing amounts in a posterior direction. The more gene product, the more posterior in appearance the form of a resultant segment.

This hypothesis is consistent with the known homeotic effects of BX-C mutations. If BX-C is deleted entirely, it supplies no gene product, and all segments behind the second thoracic differentiate as second thoracics. In a mutation with opposite effect, all the BX-C genes are turned on at once and in all segments of their action; all segments affected by it then differentiate as eighth abdominals.

The second outstanding set of homeotics is also named for its most famous mutation—the antennapedia complex, or ANT-C. The fine structure of this complex has recently been elucidated in a series of remarkable experiments by Thomas C. Kaufman, Ricki Lewis, Barbara Wakimoto, and Tulle Hazelrigg in Kaufman's laboratory at the University of Indiana. (I thank Dr. Kaufman for introducing me to the literature of homeosis and for patient and lucid explanations of his own work.) The BX-C genes regulate the morphology of segmentation from the third thoracic to the posterior end; ANT-C also affects the third thoracic, but then regulates development in the five segments anterior to it (the

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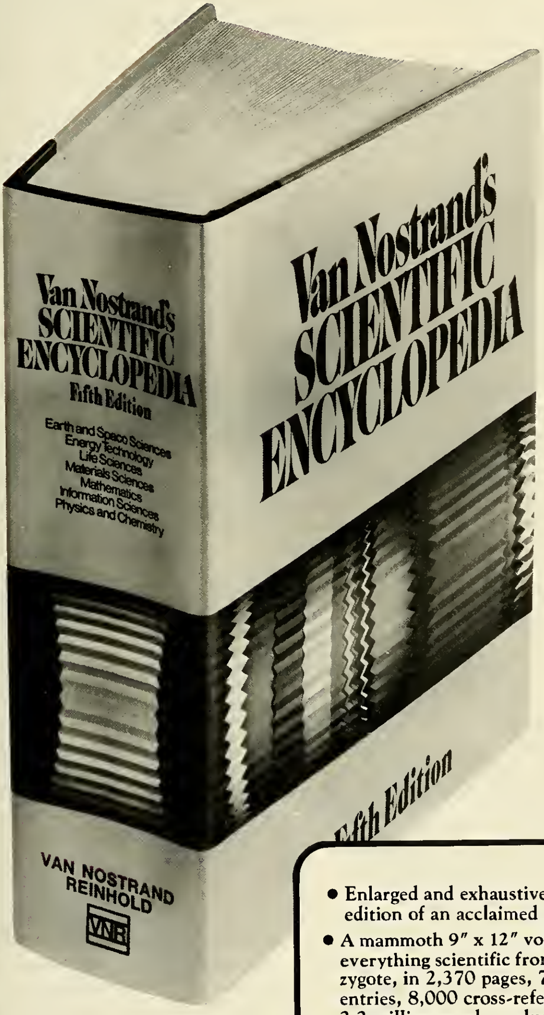
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other two thoracics and the three that produce parts of the mouth). If the entire complex is deleted, then all three thoracic segments begin to differentiate as first thoracics (while the abdominals, regulated by BX-C, develop normally). Apparently, the genes of ANT-C normally turn on in the second thoracic segment and trigger the proper development of the second and third thoracics.

Kaufman and his colleagues have found that ANT-C consists of at least seven genes, not all with known homeotic effects, lying right next to each other on the right arm of the third chromosome in *D. melanogaster*. The genes are not named for their normal effects (which, after all, just yield an ordinary fly bearing nothing special for recognition) but for their rare homeotic mutations. The first, the antennapedia gene, regulates differentiation of the second thoracic segment, and normally turns on there to accomplish its appointed function. A series of mutations has been detected at this locus, all with homeotic effects consistent with this interpretation of its normal function.

One dominant mutation, antennapedia itself, has the bizarre effect (as its name implies) of producing a leg where an antenna ought to be. This wayward appendage is not any old leg, but clearly a second thoracic. The antennapedia mutation apparently works by turning on in the wrong place—the antennal segment—rather than in the second thoracic segment.

Another dominant mutation, called extra sex combs, leads to the appearance of sex combs on all three pairs of legs, not only on the first as in normal flies. This morphology is not simply the result of a gene that makes sex combs (contrary to popular belief, very few genes simply "make" individual parts without series of complex and coordinated effects). It is a homeotic mutation. All three thoracic segments differentiate as first thoracics, and the fly has, literally, three pairs of first legs with their attendant sex combs. (The entire deletion of ANT-C also causes the three thoracics to differentiate as first thoracics, but this deletion is lethal and the fly dies in its larval stage. Flies with the extra sex comb mutation do live to become adults.) The extra sex comb mutation probably operates by suppressing the normal action of its gene. Since normal action causes the second thoracic segment to differentiate properly, suppression induces all three thoracics to develop as first thoracics.

The second gene of ANT-C is named for its prominent mutation, reduced sex comb. This homeotic mutation, contrary to the effect of its neighbor extra sex comb, causes the first thoracic segment to differentiate as a second thoracic. Only first thoracic legs bear sex combs in *D. melanogaster*. The next three genes do not have known homeotic effects, and their inclusion within ANT-C is something of a puzzle. One deletes a number of embryonic segments in its most prominent mutation, another interferes with normal development of the maxilla and mandible of the mouth, while the third produces a curiously wrinkled embryo.

The sixth gene of ANT-C is named for the other famous homeotic mutant of this complex—proboscipedia, discovered in 1933 by two of the century's most famous geneticists, Calvin Bridges and Theodosius Dobzhansky. Six mutations have been detected at this locus; most, like proboscipedia itself, produce legs where parts of the mouth should develop. The seventh and last (known) gene of ANT-C lacks homeotic effects in its mutant form and produces severe constrictions at segment boundaries in the larva. It is lethal.

Homeosis is not a peculiarity of fruit flies, but seems to be a general phenomenon, at least in arthropods. A set of mutations analogous (or even homologous) with the bithorax homeotics of *Drosophila* occurs in the silk moth *Bombyx* (order Lepidoptera; flies belong to the order Diptera). Two species of *Tribolium*, the flour beetle (order Coleoptera), exhibit mutations with effects that mimic the ANT-C homeotics of *Drosophila*. One set, in *Tribolium castaneum*, acts like antennapedia and produces a graded series of partial replacements of antennae by legs, ranging from tarsal claws on the eleventh antennal segment to the virtual replacement of an entire antenna with a foreleg. Another, in *T. confusum*, acts like proboscipedia and substitutes legs of the first thoracic segment for mouth structures known as labial palps. In the cockroach *Blatella germanica*, a homeotic mutant produces rudimentary wings on the first thoracic segment. No modern insect normally bears wings on its first thoracic segment, but the earliest winged fossil insects did!

Homeosis is easiest to demonstrate

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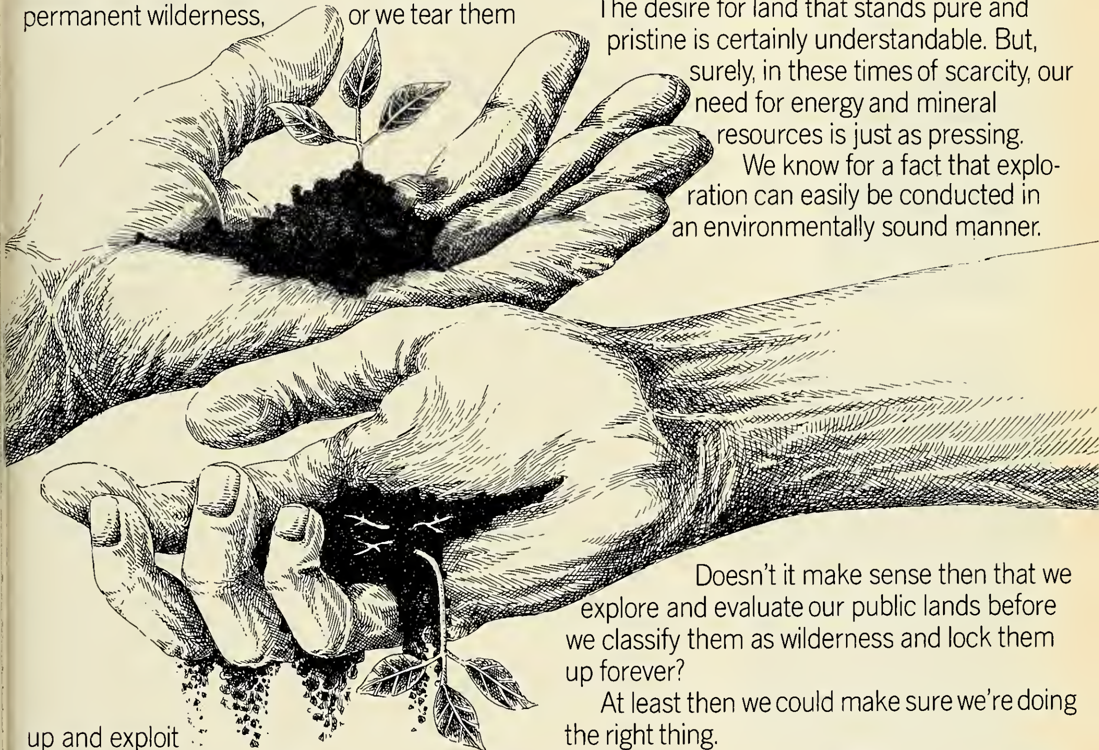

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The desire for land that stands pure and pristine is certainly understandable. But, surely, in these times of scarcity, our need for energy and mineral resources is just as pressing.

We know for a fact that exploration can easily be conducted in an environmentally sound manner.

Doesn't it make sense then that we explore and evaluate our public lands before we classify them as wilderness and lock them up forever?

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in arthropods with their characteristic body plan of discrete segments with different and definite fates in normal development, but common embryological and evolutionary origins. Yet analogous phenomena have been noted again and again in other animals and plants with repeated parts. In fact, Bateson's first example after defining the term invoked vertebrae in the human backbone. All mammals (except sloths, but including giraffes) have seven cervical, or neck, vertebrae (they are awfully large in giraffes). These are followed by dorsal, or rib-bearing, vertebrae. Bateson cites numerous cases of humans with ribs on the seventh, and even a few with ribs on the sixth, cervical vertebra.

Homeotic mutants are gripping in their weirdness, but what do they teach us about evolution? We must avoid, I believe, the tempting but painfully naïve idea that they represent the long-sought "hopeful monsters" that might validate extreme saltationist views of major evolutionary transitions in single steps (a notion that I, despite my predilections for rapid change, regard as a fantasy born of insufficient appreciation for organisms as complex and integrated entities). First of all, most homeotic mutations produce hopeless creatures. The legs that extend from antennal sockets or surround mouths in afflicted flies are useless appendages without proper neural and muscular hookups. Even if they did work, what could they accomplish in such odd positions? Secondly, the viable homeotics mimicking ancestral forms are not really forebears reborn. A bithorax fly bears the ancestral complement of four wings, but it attains this state by growing two second thoraxes, not by recovering an ancient pattern.

I believe that the lessons of homeosis lie first in embryology and then cycle back to evolution. As Tom Kaufman pointed out to me, they demonstrate in a dramatic way how few genes are responsible for regulating the basic order of developing parts in a fruit fly's body. Together, the ANT-C and BX-C complexes of *D. melanogaster* specify the normal development of all the mouth, thoracic, and abdominal segments—only the two anterior segments are not subject to their control. Each complex contains only a handful of genes and each handful may have evolved from a single ancestral gene that repeated itself several times. When these genes mutate or are deleted, peculiar homeotic effects arise that usually throw development awry and lead to death.

Most importantly perhaps, these homeotic complexes display the hierarchical way in which genetic programs regulate the immense complexity of embryonic development, recognized since Aristotle's time as biology's greatest mystery. The homeotic genes do not build the different structures of each body segment themselves. This is the task of so-called structural genes that direct the assembly of proteins. The homeotics are switches or regulators; they produce some signal (of utterly unknown nature) that turns on whole blocks of structural genes.

Yet, at a higher level, some master regulator must be responsible for turning on the homeotics at the right time and in the right place, for we know that many homeotic mutations are mistakes in placement and timing (in antennapedia, a gene that regulates normal development in the second thoracic segment turns on in the antennal segment instead). Perhaps this master regulator is no more than a gradient of some substance running from the front to the back end of a larval fly; perhaps the homeotic regulators can "read" this gradient and turn on in the right place by assessing its concentration. In any case, we have three hierarchical levels of control: the structural genes that build different parts in each segment, the homeotic regulators that switch on the blocks of structural genes, and the higher regulators that turn on the homeotic regulators in the right place and at the right time.

If embryology is a hierarchical system with surprisingly few master switches at high levels, then we might draw an evolutionary message after all. If genetic programs were beanbags of independent genes, each responsible for building a single part of the body, then evolution would have to proceed bit by bit, and any major change would have to occur slowly and sequentially as thousands of parts achieved their independent modifications. But genetic programs are hierarchies with master switches, and small genetic changes that happen to affect the switches might engender cascading effects throughout the body. Homeotic mutants teach us that small genetic changes can affect the switches and produce remarkable changes in an adult fly. Major evolutionary transitions may be instigated (although not

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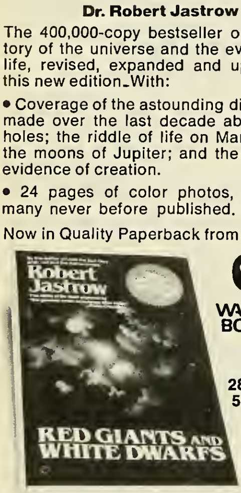

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finished all at once as hopeful monster enthusiasts argue) by small genetic changes that translate into fundamentally altered bodies. If classical Darwinian gradualism is now under attack in evolutionary circles, the hierarchical structure of genetic programs forms a powerful argument for the critics.

In this context, we consider the hypothetical major steps in insect evolution and recognize that homeotic mutants may help to illuminate them. Insects, with their relatively few, differentiated segments, probably evolved from an ancestor with more numerous and less differentiated segments. Initially, these less differentiated segments each bore a pair of legs (the antennae and mouthparts of modern insects are modified legs). Insects evolved by suppressing legs on the posterior segments and modifying them to antennae and mouthparts on the anterior segments. The major homeotic complexes of *Drosophila* seem to regulate just these changes—and with a minimum of genetic information. BX-C controls the posterior appendages with their suppressed legs, and its deletion causes these segments to begin a differentiation as second thoracics with incipient legs. The major mutants of ANT-C replace structures that were once legs with legs. The nature of homeotic changes is not capricious, but follows evolutionary channels.

Even the bizarre homeotics may not be devoid of evolutionary information. When Bridges and Dobzhansky described proboscipedia in 1933, they noted that a large set of coordinated changes—quite apart from the spectacular appearance of legs—all brought the mouthparts closer to the standard form of biting insects from which the flies presumably evolved. (Dobzhansky, who died just a few years ago, was the greatest evolutionary geneticist of our times. Fancy, quantitative lab work often wins all the kudos while field naturalists, with their detailed and specific knowledge, are unfairly dismissed as stamp collectors. Dobzhansky's life proves how contemptible this prejudice is. Geneticists had been describing homeotic mutants for years, but none had the knowledge to recognize the subtle morphological effects that require a trained taxonomist's eye to comprehend. Dobzhansky, the finest geneticist of them all, was a trained taxonomist and field biologist who began his work by specializing on the systematics of the Coccinellidae, or lady beetles. There is no substitute for detailed knowledge of natural history and taxonomy.)

If anyone has wondered whether homeotic mutants must find their significance only in highfalutin realms of evolutionary speculation, I close with an arresting fact. A homeotic mutation has been found in the biting mosquito *Aedes albopictus*. Yes, you guessed it. This mutation converts part of the biting apparatus into a pair of legs! The six stylets that actually pierce our skin are unaffected, but the labella, the structures that surround the stylets and contain tactile and chemosensory hairs, are converted to legs with tarsal claws at their tips. These mosquitos cannot pierce skin, both because they lack the tactile and chemosensory hairs that locate the right spot and because the stylets get entrapped in the misplaced legs.

What a wonderful and joyous idea in a world inundated with bad news—an ouchless mosquito with an extra pair of legs. Oh, don't raise your hopes. They won't replace the normal ones. First of all, they die because they cannot feed (although they can be artificially maintained on blood-soaked cotton balls). Even if they learned to feed by lapping instead of piercing, they would be no match for the normal kind because they have longer larval lives, increased pupal mortality, and a significant decrease in adult longevity. Still, these are the curious facts that nurture hope in parlous times—in this case, and with only a little poetic license, an enormous advantage (if only for another long-suffering creature) of putting a foot in one's mouth.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

My article, "Dr. Down's Syndrome," published in the April 1980 issue, was an expansion of part of a chapter on nineteenth-century anthropometry that I wrote in 1978, and will appear in my forthcoming book, *The Mismeasure of Man*. Dr. Carolyn Fluehr-Lobban of Rhode Island College, who wrote an excellent and far more extensive article on Down's Syndrome in 1979—"Down's Syndrome (Mongolism), the Scientific History of a Genetic Disorder"—has asked me to add this citation of her manuscript to the acknowledgement of her help already published in my original article.

*S.J.G.*

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# Fatness, Puberty, and Fertility

*Stored fat appears to regulate reproductive ability in the human female*

**by Rose E. Frisch**

Charles Darwin observed, more than a hundred years ago, that "hard living retards the period at which animals conceive" and, conversely, that "the more vigorous and better-nourished individuals of a species would be ready to breed in the spring before the others." He also noted that domestic animals, which have regular, plentiful food without working to get it, are more fertile than the corresponding wild animals, and that an individual animal's fertility is affected by variations in the amount of food. Darwin's common-sense description of the relationship between nutrition, "hard living," and fertility also applies to human beings, as an examination of historical trends and current findings will show.

A.M. Carr-Saunders, in his classic book *The Population Problem*, gives many examples from hunting and fishing societies to show that poor living conditions limit human fecundity, or reproductive ability, and better conditions enhance it. Recognizing the general principle for all species, he states:

> Fecundity has been spoken of as if it was fixed at a certain strength for each species. As a matter of fact, it varies within fairly wide limits—increasing with better conditions. In this fact lies the explanation of the increase of species under favorable conditions which has often been observed, although when conditions are less favorable, there is little or no evidence of starvation among such species.

When food supplies are inadequate, women and men, like other animals, are less fertile. When food intake is very low, reproduction stops. The individual does not reproduce the species at any cost.

Differences in the natural fertility of human populations have long been recognized. These have usually been attributed to differences in length of birth intervals or variation in general health and food intake, without explanation of how this regulation is achieved. In recent years, scientists have sought to specify the biological mechanisms involved. My own research has been concerned with the discovery, with Janet W. McArthur, that the onset and maintenance of regular menstrual cycles in women are dependent on the attainment and maintenance of a minimum weight for height, apparently representing a critical level of fat storage. A particular body composition—a certain ratio of fat to lean or of fat to body weight—proves to be an important determinant of fecundity in the human female.

We found that a woman who loses about 10 to 15 percent of her body weight—thereby losing about a third of her body fat—becomes amenorrheic, that is, her menstrual cycles cease. An excess of body fat also affects menstrual function, since other studies have shown that very obese women also become amenorrheic or have irregular cycles. Too little fat or too much fat, therefore, is associated with a disruption of female reproductive ability. My research, which has been concerned with the effects of excessive thinness, suggests that a minimum level of stored, easily mobilized energy, such as fat, is necessary for ovulation and menstrual cycles and for a successful pregnancy and lactation (nursing). Chronic or acute undernutrition and the energy drain of hard physical exercise can directly affect female fertility far more than has been realized. Male fertility also is affected by undernutrition, but in a pattern different from that for women.

Quantitative interest in the body in relation to nutrition, growth, and reproductive ability in both sexes first became strong in the nineteenth century, probably inspired by the pioneer work of the Belgian mathematician Adolphe Quetelet. In the earlier Malthusian view, human reproductive power was an irrepressible force, fulfilling itself regardless of circumstance, to be cut down by the positive check of increased mortality or held in check by the moral restraint of late marriage. In contrast, the medical and biological literature of 1850 to 1880 assumed that reproductive ability in both sexes is directly related to the state of vigor or decrepitude of the reproducing individuals. British medical texts up to about 1885 emphasized that constitutional conditions are more important, and more prevalent, causes of sterility than diseases of the organs. Doctors realized that sterility may serve a protective function: if a woman deficient in reproductive energy did get pregnant, there would be a high risk of miscarriage or of sickly children or of the death of the mother.

The degree of pinguidity, or fatness, was known to be important in relation to sterility. "She's too thin" to get pregnant or to menstruate regularly was a common observation, especially in association with tuberculosis or chlorosis, a virulent anemia common among working women. The prescription was to "recover her flesh" by puddings and roast meats, good wine, and fresh air and sun. "She's too fat to get pregnant" was also observed; in such cases, a light diet and exercise were prescribed. Alcoholism too was already correctly perceived as a cause of sterility.

Undernutrition and hard work were recognized as being related to the high incidence of menstrual disorders. About a quarter of the women working in mills apparently suffered from either retarded or suppressed menses, and about half of all married women between the ages of 20 and 45 were reported to have "diseases of the uterus," including amenorrhea. The main causes of amenorrhea, according to doctors, were those that "impair the constitutional tone and impoverish the blood": poor diet, disease (particularly tuberculosis and chlorosis), unsuitable employment, and cold and damp. Doctors noted that working-class women were underweight and amenorrheic because of poverty; upper-class women because of their desire to be fashionably thin. Stress ("violent fits of passion") was also implicated as a cause of amenorrhea.

Perhaps owing to their awareness of the life cycles of domestic animals, many nineteenth-century doctors re-

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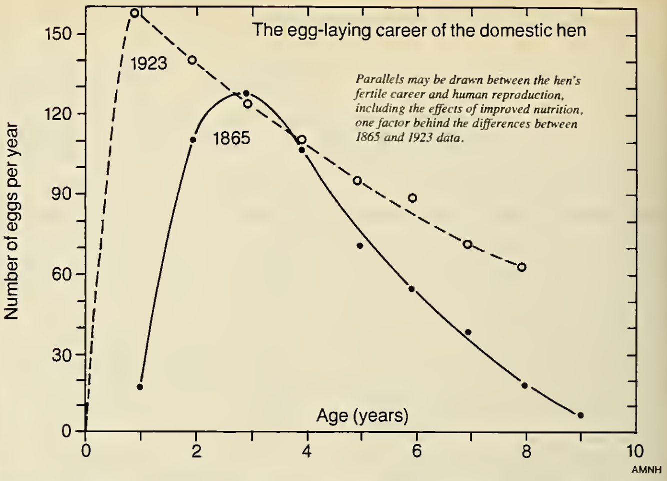

*Parallels may be drawn between the hen's fertile career and human reproduction, including the effects of improved nutrition, one factor behind the differences between 1865 and 1923 data.*

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alized that, in addition to the direct effects of nutrition and hard living on reproductive success, there is an optimal reproductive stage related to physical growth and the coordinated growth of the genital organs. J. Matthews Duncan, speaking before the Royal College of Physicians about a century ago, observed that if a female, human or cattle, is bred too young, "it is at the expense of the completion of normal growth" and may result in both inferior offspring and the death of the mother.

Duncan had studied the fertility of Scottish women in order to find the age of reproduction of least risk to the mother. He observed that the fertility of women gradually increases with age to a climax and then gradually wanes, similar to "the fertile career of the domestic hen." As in the hen, reproductive errors are more frequent at the beginning and end of the fertility curve, and underfeeding and overfeeding will diminish fertility.

The reproductive career of the mid-nineteenth-century British female began with menarche, the onset of menstrual cycles, at about 15 to 16 years of age. Age of menarche differed by social class: girls of the upper socioeconomic classes matured before the poorer girls. Today, the average age of menarche of British girls is about 13 years of age, while for girls in the United States the average age is 12.6 to 12.8. (It should be emphasized that any "average age" reflects a great deal of natural variation, and that even under optimal conditions, there are differences in individual rates of growth attributable to normal, genetic variation.) It was observed that following menarche there was a period of relative infertility, now termed adolescent sterility, or adolescent subfecundity. This period lasted until the completion of physical growth at about age 22, when the first stage of nubility, the "fitness for procreation," as Duncan described it, was attained. Then came the rise to the age of peak nubility, or "best fitness for procreation," at age 25 to 29. This was the age of full physical vigor when a woman had the best chance of surviving her first birth. The risk of maternal mortality and of infant mortality or congenital deformities, high at menarche, decreased up to the age of peak nubility and then increased as the mother became older.

The fertility curve descended gradually to the cessation of childbearing at about 40 years of age, and then to the cessation of menses, the menopause, at about age 47. The premenopausal "turning-off" period is analogous to the postmenarcheal "turning-on" period of adolescent subfecundity. In the mid-nineteenth century, these periods were of about equal length, six years. Nowadays, the period of adolescent subfecundity averages only three or four years, while the period of premenopausal subfecundity has increased to seven or eight years. Both types of reduced reproductive ability are characterized by the absence of ovulation or other disturbances of the normal cycle.

The average age of menopause in about 1850 was approximately 47 years, earlier than that of present-day, well-nourished women, for whom it

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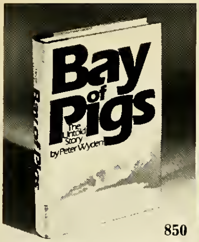

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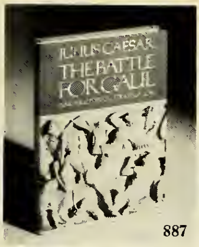

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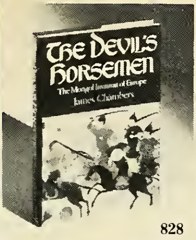

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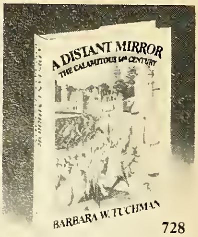

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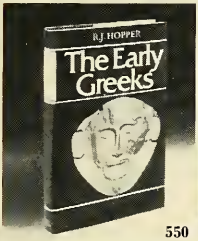

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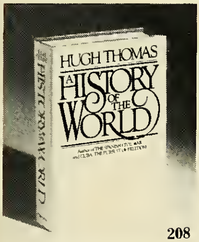

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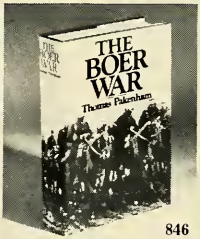

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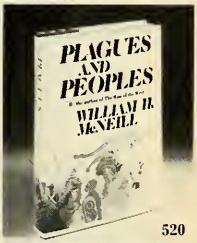

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averages about 50 to 51. The extent of this secular, or long-term, change in the age of menopause—about three years—is comparable to the change in the age of menarche in the last one hundred years.

In the nineteenth century, lactation was understood to regulate the birth interval in the human female, as in other mammals, by retarding the birth of the next offspring. The length of the birth interval determines the ultimate size of the family and the health of the mother and child. A hundred years ago, the average birth interval of about two years was considered biologically natural. It was already known, however, that the birth interval lengthened as the mother became older and that women "low in fecundity" bred at greater intervals at all ages, beginning with the first birth.

The historical curve for reproductive ability, or procreative power as it was termed in the nineteenth century, is more speculative for males than for females, but the time of beginning and the peak are reasonably well estimated from the data on the times of fastest growth in height and completion of growth, in relation to the female ages. Peak fecundity in British males in the mid-nineteenth century occurred at about 31 to 33 years of age, compared to age 25 to 29 for females. Genarche, the male equivalent of menarche, most probably occurred at about age 17 to 18.

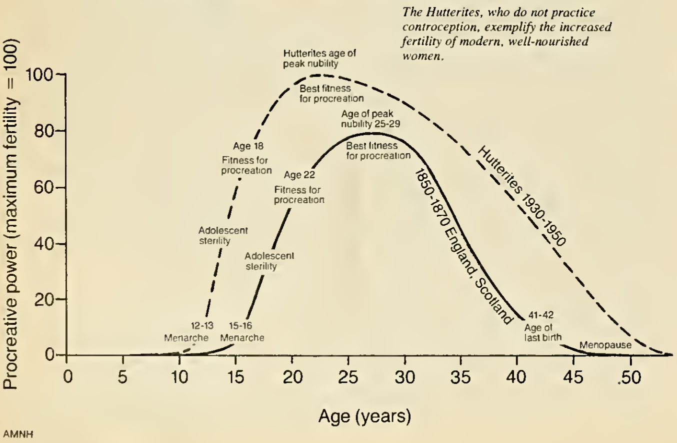
Most men of the British lower social classes did not complete height growth until age 23 to 25. Even upper-class men were relatively late, 21 to 23 years old, compared to the present age of completion, 18 to 20, for well-nourished males in Western countries. Most British women did not complete their growth in height until age 20 to 21, compared to age 16 to 18 today.

Height data from Norway corroborate the class differences in growth and maturation found in mid-nineteenth-century Britain. In addition, the data show the direct effect of an increase in food supply (for example, the introduction of the potato) in valleys in Norway on the height of army recruits and on the age of male and female sexual maturation. The better the food supply, the earlier the maturation.

The age, height, and weight for army recruits were much discussed and carefully chosen in relation to age of adult physical maturation. The British army doctors who passed on recruits were told that too young an age of recruiting and not enough men at the "acme of virility"—35 years—led to catastrophe. Poorly fed recruits, the ones most likely to join the army to collect a bounty, were a bad risk since they were physiologically younger than their chronological age. These men were slow to complete their growth, so their "limb power" and heart volume were immature. On long marches these were the men who fell by the wayside or had to be hospitalized. Recruits should be at least 20 to 21 years old—then they will be bone and muscle, "not almost gristle," as Lord Henry Hardinge complained of recruits under 19 years old arriving in the Crimea.

Although historical data do not exist on the direct effects of nutrition on male reproduction, we know from modern studies that severe undernutrition results in loss of libido, a decrease in prostate fluid, a decrease in sperm mobility and longevity, and eventually, the cessation of sperm production, in that order. Undernutrition also delays the onset of sexual maturation in boys, as in girls.

The trend toward a longer and more fertile reproductive career



*The Hutterites, who do not practice controception, exemplify the increased fertility of modern, well-nourished women.*

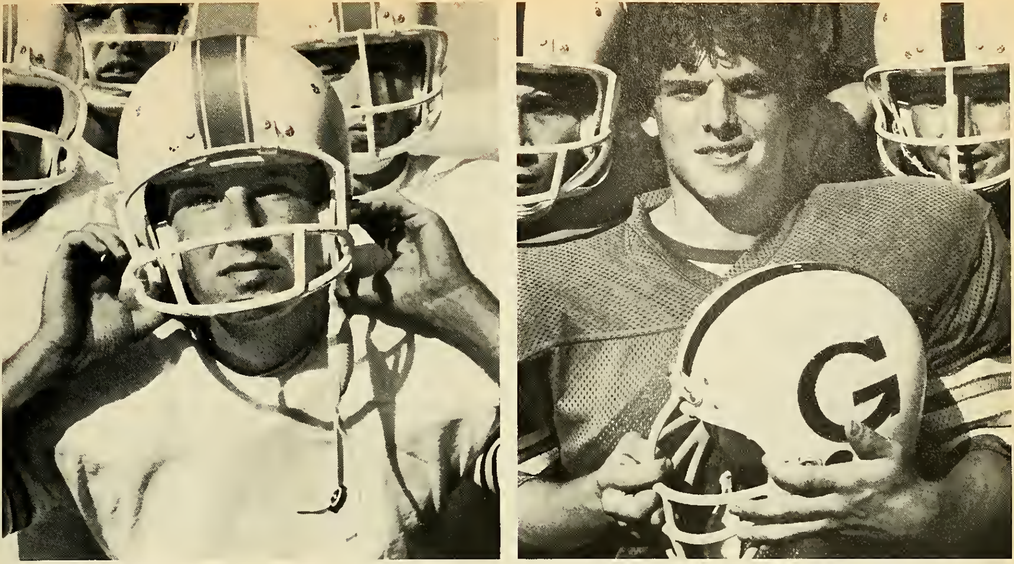
AMNH

Recently, scientific studies have begun to provide an understanding of the biological mechanisms involved in the direct effects of nutrition on fertility. The idea that relative fatness is important for female reproductive ability grew out of the earliest results of my research with Roger Revelle on menarche and adolescent growth. We found that the events of the adolescent growth spurt in boys and girls, and particularly menarche in girls, were each closely related to a critical average body weight. This finding was unexpected for human beings although it was well known that for other mammals, including primates, sexual maturity (defined by vaginal opening or, more precisely, first estrus) is more closely related to body weight than to chronological age.

Our study of the growth patterns of girls in the United States showed that the average weight at menarche, about 103 pounds, did not differ significantly for early- and late-maturing girls, whereas the late-maturing girls were on average taller than those who matured earlier. These results confirmed the many reports in the literature that early maturers have more weight for height than do late maturers.

Even before taking the next step—exploring the meaning of the critical weight for an individual girl—the idea that menarche is associated with a critical weight for a population explained many observations associated with early or late menarche. Observations of earlier menarche are associated with attaining the critical weight more quickly. The most important example is the secular, or long-term, trend to an earlier age of menarche in the United States and Europe of about three or four months per decade in the last one hundred years.

The average age of menarche of United States girls is now 12.6 to 12.8 years. In contrast, a hundred years ago the average age of menarche was about 15.5 to 16. (The medical definition of precocious puberty has changed accordingly: in 1850 to 1870, precocious puberty was defined as 11



# One of these helmets came off the field and off the market when the rules of the game changed.

Not the football rules, but the rules of the legal system under which manufacturers can be sued for damages. In recent years, courts have been inclined to hold a product manufacturer or distributor liable for injuries even when the company had met safety standards or when the injured person was negligent in using the product.

As a result, judgments, settlements and legal costs in liability cases have increased dramatically. Businesses are faced with uncertainty in trying to gauge the extent of their exposure to lawsuit. When these factors outweigh the benefits of making a product, that product will leave the marketplace.

That's what happened to the manufacturer of the helmet on the right. He stopped production of helmets until, as he says, the legal climate changes in the United States. It has happened also to some makers of vaccines, plastic products and machines. Right now, the chemical and pharmaceutical industries are deeply concerned about the potential financial impact of recent court decisions.

As a major group of property and casualty insurance companies, we, too, are concerned about this problem. Our companies provide insurance designed to protect business from financial loss resulting from a lawsuit. This protection normally encourages business to remain in the marketplace. It enables manufacturers to develop new products, to provide more jobs and generally to contribute to our economy.

But the trend in legal judgments threatens all that stability. As lawsuit settlements and awards become higher, insurance companies tend to be more cautious in writing insurance coverage. And they must charge more for it. That in turn causes manufacturers and sellers to raise their prices to cover the increased cost of insurance protection. Which means that consumers pay more for what they buy.

It's frustrating, but not hopeless. Steps can be taken to prevent injuries and to control the rise of liability costs. And that would benefit everyone.

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and 12 years of age; at present, it is defined as ages 8 and 9.) The average weight at which menarche was attained in a population, however, was the same a hundred years ago as today. Our explanation of the secular trend, supported by historical data, is that children now are bigger sooner. Therefore girls (considered as a group) more quickly reach 101 to 103 pounds, the average weight at menarche in the United States and many European populations (such as the English, Dutch, and Finnish). According to this hypothesis, the secular trend should end when the weight of children at any given age level (for example, all 12-year-olds) does not differ in successive years owing to the attainment of maximum nutrition and child care. This may now have happened: the average age of menarche of girls in this country is the same today as about thirty years ago for well-nourished girls.

Conversely, a late menarche is associated with body weight increase that is slower prenatally, postnatally, or both, so that the average critical weight is reached at a later age. For example, malnutrition delays menarche; twins have a later menarche than do singletons of the same population because they grow more slowly; and high altitude delays menarche by slowing the rate of weight growth both in utero and after birth. Some of the latest recorded average ages of menarche in the world, 17 and 18 years, are of high-altitude, poorly nourished populations.

The weight dependency of menarche in human beings, as in animals, operates as a compensatory mechanism for both environmental and genetic variation. The result is a reduction in the variability of body size at sexual maturation. Like that of many other animals, human body size at sexual maturation is close to adult size: weight and height at menarche are 85 percent and 96 percent of adult weight and height, respectively. The regulation of female body size has obvious selective advantages for the species since birth weight is correlated with the prepregnancy weight of the mother, and infant survival is correlated with birth weight.

In order to understand how critical weight at menarche operates for the *individual* girl, it is necessary to see how, during the slow, long-term maturation of the reproductive system, the growing body changes not only in size and shape but also in the proportions of the tissues. A fundamental aspect of "growing up" is the change in the relative weight of water, protein, bone, and fat in the body. These adjustments accelerate during the adolescent growth spurt.

Research by others suggested that in mammals changes in metabolic rate and stored fat may be related to sexual maturation. My colleagues and I therefore analyzed the components of body weight—water, lean body mass (which includes the skeleton), and fat—for individual girls. Estimation of body composition showed that the greatest change, by weight, in both early- and late-maturing girls, during the adolescent growth spurt up to menarche, is a 120 percent increase in body fat, from about eleven pounds to twenty-four pounds. Lean body weight, in contrast, increases only about 44 percent. The ratio of lean body weight to fat thus changes from 5:1 at initiation of the spurt to 3:1 at menarche.

Water becomes a lower percentage of the body weight as fat becomes a larger percentage since fat contains little water. At menarche, girls average about 55 percent water and about 24 percent fat. At the attainment of mature height and weight, at 16 to 18 years of age, an average well-nourished young woman in the United States (height 65 inches, weight 125 pounds) is about 52 percent water and 28 percent fat. The completion of height and weight growth coincides with the end of the period of adolescent subfecundity, when the ovary, uterus, and oviducts have also completed their growth. An average United States male is considerably leaner at the completion of growth (at about 18 to 20 years of age), being about 61 percent water and about 14 percent fat.

Reproduction requires energy. A pregnancy requires a total of about 50,000 extra calories, and lactation about 1,000 extra calories a day. In prehistoric times, successful lactation was an absolute necessity for the survival of the infant. The main function of the thirty-five pounds of fat stored on average by both early- and late-maturing girls by age 18 may be to provide easily mobilized energy for reproduction. The 144,000 calories stored at the time of mature reproductive ability would be sufficient for a pregnancy and about three months' lactation. The human brain, it should

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be noted, grows most rapidly during the last trimester of pregnancy and the first months after birth.

The research on the changes in relative fatness in normal, well-nourished females provided standards to assess weight changes in girls and young women undernourished by injudicious dieting and in patients with the psychogenic disease anorexia nervosa. Our investigation showed that a minimum weight for height, representing about 17 percent fat of body weight, was necessary for menarche, and that a heavier minimum weight for height, representing about 22 percent fat of body weight, was necessary for the maintenance or restoration of regular ovulatory cycles.

We found that the weights at which menstrual cycles cease or resume in young women age 16 and older are about 10 percent heavier than the minimal weights for the same heights observed at menarche. For example, a young girl 63 inches tall should weigh at least 91 pounds before menstrual cycles would be expected to start. In comparison, a 20-year-old amenorrheic woman of the same height will normally have to weigh at least 102 pounds before menstrual cycles can be expected to resume. The heavier postmenarcheal weight reflects the 10 additional pounds of fat added during the period of adolescent subfecundity. (At present, our standards apply only to United States and European females, since different populations have different critical weights at menarche, and researchers do not as yet know whether the different critical weights represent the same critical body composition.)

It is important to note that other factors, such as emotional stress, affect the onset and maintenance of menstrual cycles in human beings. Therefore, menstrual cycles may cease without weight loss and may not resume in some women even though the minimum required weight is attained.

High energy outputs, in addition to low nutritional intake, interact with fatness to affect female menstrual periodicity. Women ballet dancers and athletes who train intensively have a high incidence of amenorrhea. In runners, the incidence is directly related to weekly training mileage. When intensive training begins at an early premenarcheal age, menarche may be delayed until as late as age 19 or 20. Studies of dancers show that menarche may occur after an injury that

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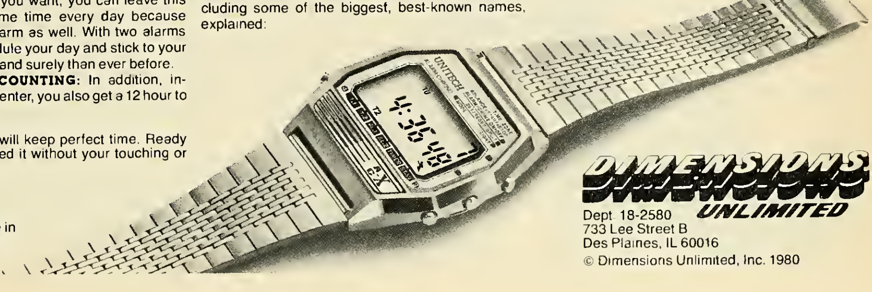

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requires the suspension of training for a month or two.

Hormonal changes observed in women amenorrheic because of excessive thinness correlate with the changes in weight and body composition. A return to a prepubertal pattern of hormone secretion is found with the reversion to a prepubertal body composition of lean to fat. The close association between the hormonal secretory pattern and changes in body composition suggests that there is some signal from the central nervous system to the hypothalamus, a part of the brain that controls the eventual release of gonadal hormones.

From an evolutionary view the economical and reasonable hypothesis is that physical ability to reproduce successfully and hypothalamic control of reproduction are synchronized by the central nervous system. Both the absolute and relative amounts of fat are important since the lean body mass and the fat obviously must be in a particular absolute range, as well as a relative range, that is, the individual must be big enough to reproduce. It has recently been found that transformation of androgens to estrogen takes place in human breast and abdominal fat, suggesting that adipose tissue may be a significant extragonadal source of estrogen. Body weight, hence fatness, also influences the direction of estrogen metabolism to the most potent or least potent forms. The high percentage of fat in the mature human female thus may directly influence reproductive ability.

Food intake and ovulation also may be related in a particularly interesting way, as is evident in the phenomenon of "flushing" found in sheep. Flushing is the increase in the rate of twinning resulting from short-term (for example, a week) high-caloric feeding by the ewe before mating. The well-nourished human female, fortunately, does not normally superovulate in response to a high caloric intake. However, some women may be sensitive to a food intake signal. When nutrition was severely restricted during World Wars I and II, a decrease occurred in the rate of human dizygotic twinning (nonidentical twins from two fertilized eggs). There was no change, however, in the rate of monozygotic twinning (identical twins from one fertilized egg). The rate of dizygotic twinning returned to normal after food supplies returned to peacetime levels.

We still have much to learn about the mechanisms involved, both for the individual and for populations. As we have seen, the British historical data on nutrition, growth, age of menarche, birthrate by age of the mother, incidence of sterility, birth interval, and age of menopause, show that slow growth to maturity of women and men due to hard work and disease is correlated with a reproductive span that is shorter and less efficient than that of a well-nourished population. But why is a late menarche in a population usually associated with an earlier menopause, with long lactation intervals, and with higher pregnancy wastage? Are there exceptions in some environments to these associated events? How much is reversible after growth is completed?

One endocrinological explanation for these interactions is suggested by experiments in which my colleagues and I fed animals high-fat and low-fat diets that substituted fat isocalorically for carbohydrates. The animals on a high-fat diet reached sexual maturation significantly earlier and were relatively fatter than the animals on a low-fat diet. The well-nourished human female, particularly on a diet with a high percentage of calories from fat, may have higher estrogen levels, which result in a higher reproductive efficiency than is found in females with less adiposity.

Whatever the mechanisms, the fact that undernourished human beings and animals are less fecund than well-nourished populations can be regarded as an adaptation to reduced food supplies and of ecological advantage. Reduction of fertility as a result of undernutrition and hard living is a less wasteful mechanism than the regulation of overpopulation by mortality. Of course, in the case of humans, there are also social customs—such as a late age of marriage or a taboo on intercourse during lactation—which affect the rate of pregnancy in a particular society.

The Bush people of the Kalahari Desert today demonstrate the type of reproductive pattern found in nineteenth-century Britain. The Bush people are not starved, but their caloric and protein intake fluctuates seasonally and averages significantly less than that of well-nourished people of developed countries. Sociologist Nancy Howell has found that a Bush woman has an average of less than five living births in her whole reproductive span. A well-nourished United

States woman who does not use contraceptives, such as a Hutterite, averages eleven to twelve children, beginning at a later age of marriage.

Former explanations of the relatively small size of the Bush family have included venereal disease and abortion. Strong support for the alternative explanation of a lower level of reproductive ability is found in the changes that take place when Bush women move to trading posts. There, women eat a higher calorie diet; they also no longer expend so much energy in food gathering. Among these migrants, the age of menarche is becoming earlier and the birth interval is shortening; natural fertility therefore is increasing.

If subfecundity was the main reason for the relatively low observed fertility among British working-class couples in the nineteenth century, a reasonable question is, Who at that time was using the many (inefficient) methods of contraception devised during human history? The data suggest that contraception would have been used by females (and males) who were well nourished, hence fully fertile, and whose reproductive ability exceeded their desire for offspring. This would be a small percentage of the population: the relatively well-fed aristocracy, especially those who used wet nurses; the wet nurses themselves, since pregnancy would affect their ability to nurse; and prostitutes, whose aspirations of fertility were zero.

Undernutrition may have been one of the reasons for the relatively low fertility observed in nineteenth-century Britain. Undernutrition, instead of widespread use of folk contraception, may also explain the completed family size of six to seven children found in many developing countries today. If so, the nutrition programs necessary for a vigorous, productive society should be closely integrated with family planning programs for the well-being of the mother, the child, and the society. The research on the direct pathway from nutrition to fertility implies that when couples are well fed, and their potential fertility is high, there is interest in, and receptivity to, the idea of efficient means of contraception.

*Rose E. Frisch is a lecturer in the Department of Population Sciences and the Center for Population Studies of the Harvard School of Public Health, Cambridge, Massachusetts.*

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# Moas and the Maori

*Unraveling the evolution and extinction of a large, flightless bird*

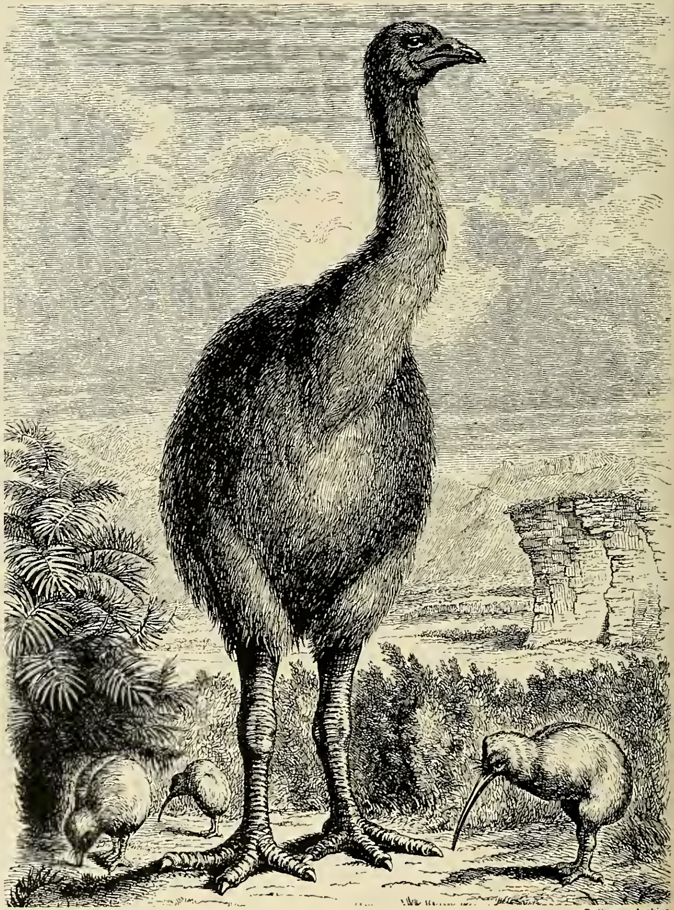
**by Joel Cracraft**

On a wintry day in early February 1844, a large crowd assembled at the Royal Institution in London to hear a lecture about some old bird bones recently arrived from New Zealand. As was the custom, the gentlemen were at their attentive best on the main floor, the ladies were in their proper Victorian place high up in the gallery, and the physicist Michael Faraday was prepared to serve tea at the conclusion of the festivities.

That the famous of London's scientific and literary society (Dickens and Carlyle were often in attendance at such functions) would spare the time to learn the latest about bird bones may seem curious, but the lecturer was none other than Prof. Richard Owen, England's premier anatomist and paleontologist. And these were not ordinary bird bones he was to talk about—they were the relics of giant flightless birds that were thought to be, as Owen's wife was to characterize them in her diary, the "only remaining types of a large creation as proper to an early state of the globe."

The intellectual community's keen interest in these birds had its origins five years earlier. In 1839 Owen had stunned his fellow scientists by describing a fragmentary scrap of limb bone, brought to him by a sailor just returned from New Zealand, as having come from a previously unknown form larger than an ostrich. When Owen submitted his paper to the Zoological Society of London, the publication committee protested strongly. After all, how could one reconstruct a giant flightless bird from such a small scrap? And how could such a large bird have escaped the eyes of several generations of New Zealanders? The bone was not fossilized, so if Owen was correct, the living bird surely would have been observed by someone. Finally, however, at Owen's insistence—and at some risk to his reputation—the paper was published, and copies were distributed across New Zealand. Four years later more bones arrived from naturalists in New Zealand, and Owen had the proof he needed. Over the next forty years, he and others described dozens of species representing forms the size of a turkey to those standing taller than an ostrich.

How did these birds, called moas from the Polynesian word for fowl, come to occupy New Zealand? What factors facilitated their evolution, which resulted in remarkable taxonomic and morphological diversity? And why did they become extinct? These and other questions have puzzled scientists for more than a century, but only within the last decade have biologists and anthropologists begun to



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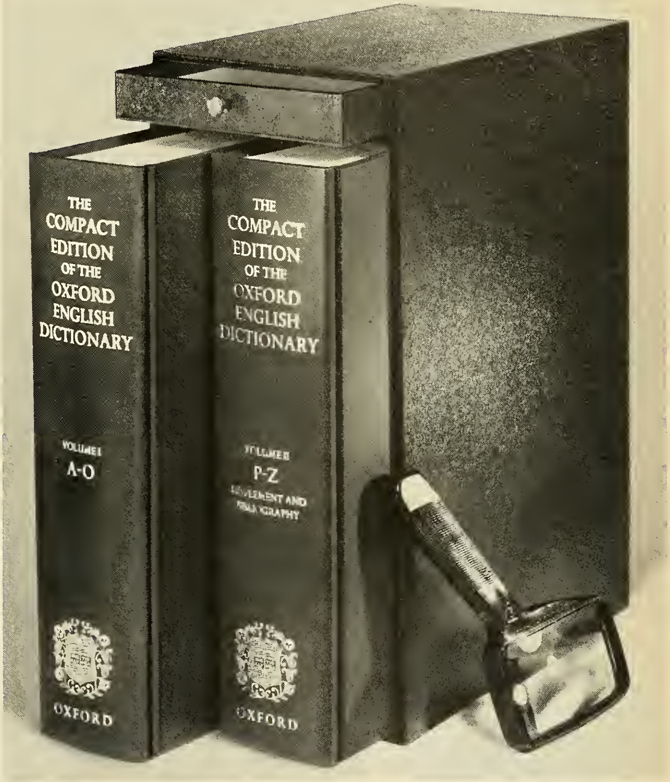
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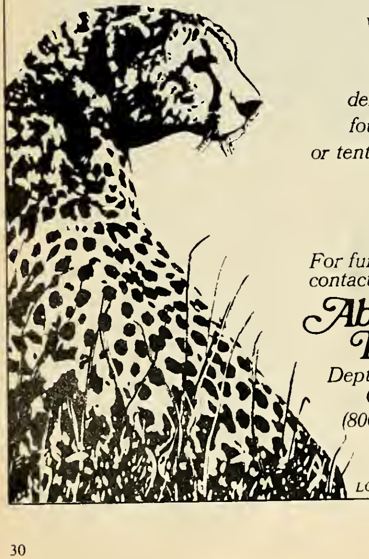

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furnish some satisfactory answers.

Moas belong to a group of birds known as ratites; included in this group are the rheas of South America, the ostriches of Africa, the extinct elephant birds of Madagascar, the emus and cassowaries of Australia and New Guinea, and the kiwis of New Zealand. Except for the kiwis, all these birds are large, flightless, and look much alike. Many experts, even as recently as fifteen years ago, considered them to be unrelated to one another. These workers hypothesized that each species had its own distinct ancestor, which flew to these far-flung southern landmasses and independently evolved large body size and flightlessness. Not unexpectedly, this hypothesis had special appeal to a scientific community that, at the time, accepted the notion of stable continents and ocean basins.

Then, in the 1960s and 1970s, ornithologists began to reinvestigate the comparative morphology, behavior, and biochemistry of these birds. All the available evidence provided by these studies supports a hypothesis of common ancestry for the ratites and a close relationship between them and the tinamous of South America, a family of grouselike birds capable of flight. Moreover, on the basis of morphological data, biologists have postulated that rheas and the ostriches are each other's closest relatives and that they, in turn, are related to the emus and cassowaries. These four families, furthermore, appear to share an ancestry with the elephant birds, and finally, all five can be related to the kiwis and moas.

This hypothesis of relationships has some important implications, two of which seem to answer the question about the origin of the moas. For example, the hypothesis implies that ratites evolved large body size and became flightless only once, near the beginning of their ancestry. The second implication is that ancestral ratites were rather widespread over a united Southern Hemisphere landmass. When the continents began to break up and drift apart in the middle to late Cretaceous (about 80 to 130 million years ago), progenitors of the modern families were isolated.

In the Cretaceous, a continental mass, which later became New Zealand, lay connected to the Ross Ice Shelf region of West Antarctica. Topologically and geologically distinct from East Antarctica, West Antarctica was apparently united intermittently not only to the New Zealand continental block but also to the southern Andean portion of South America. It can be postulated that at some time in the late Cretaceous an early ratite ancestor was distributed over a common New Zealand-West Antarctica-southern South America landmass. With the northward drift of New Zealand, beginning about eighty million years ago, that ancestor became isolated. A subsequent evolutionary event within the New Zealand continental fragment produced the lineages leading to moas on the one hand and kiwis on the other.

Moa bones are known from natural deposits 600 to 33,000 years old and from sites associated with human activity, all of which are less than 1,000 years old. These remains are now classified into six genera and about thirteen to fifteen species. The genera are characterized by differences in body proportions and in the shape of the head and bill, suggesting that the species of each genus had a distinct method of obtaining food. Within each genus, however, the species are differentiated from one another primarily on the basis of size. This twofold aspect of evolutionary divergence—by shape among genera and by size within each genus—has produced a remarkable radiation in morphological diversity. As an example, the genus *Dinornis* contains four medium (five to six feet tall) to very tall (nine to ten feet) species, all of which have broad, flattened skulls and bills and extremely thin legs for birds their size. The genera *Euryapteryx* and *Pachyornis*, on the other hand, have two species each—one small (three to four feet) and one medium to large (five to seven feet)—and are robust, heavy-boned birds with deep, strong skulls and beaks. The remaining genera, *Megalapteryx*, *Anomalopteryx*, and *Emeus*, consist generally of smaller species (four to five feet tall) with relatively weak bills of varying shape. (Another interesting morphological characteristic of moas is that they are the only group of birds known to have lost all the bones of their wings.)

How can this pattern of species and morphological diversity be explained? The answer to this question probably has two components, one relating to paleogeographic and paleoclimatic changes that took place during the Tertiary and Pleistocene and the other to the ecological interactions that occur among species faced with exploiting similar and restricted resources. As is frequently the case in paleontological

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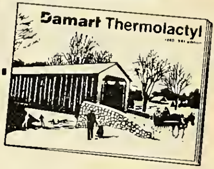

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reconstructions, both components can be inferred to have been important in moa evolution, but constructing rigorous tests of these hypotheses may prove impossible.

Biologists have established that new species can arise when populations of previously existing species are fragmented in some manner by climatic or geographic barriers. Once in isolation, these fragmented populations diverge, either rapidly or slowly, to become distinct species. One key to a rapid proliferation of species within a restricted geographic area—called an evolutionary radiation—is the occurrence of cycles of population fragmentation, divergence in isolation and reunion of these newly evolved species, followed by another cycle of fragmentation and isolation. In this way an original species gives rise to two or more new species in isolation; then when barriers are eliminated, some of these species may come to occupy the same area. If new barriers arise, the population of each new species is fragmented and additional species evolve. Diversity can thereby increase rapidly.

We can hypothesize that this model of species evolution provides an explanation for the taxonomic diversity of moas. Throughout the Cretaceous, and especially during the Cenozoic, the New Zealand landmass was constantly changing in surface area and topographic features. As the New Zealand continental plateau drifted slowly northward, islands of various sizes and shapes emerged, became united to form large land areas, and were divided once again by rising sea levels. There are at present only two major islands, North Island and South Island, but a series of islands existed for varying periods of time in the early and middle Cenozoic. And in the Pleistocene, the cyclical changes in sea levels, which were correlated with the waxing and waning of the polar icecaps, repeatedly separated and then joined North Island and South Island. This then is the paleogeographic setting that undoubtedly influenced moa evolution. Given the frequency of geographic isolating events that took place during the last forty or fifty million years, it is not surprising to see high species diversity in a group of birds. What makes the radiation of moas interesting, however, is that it involved taxa of large body size and took place on a relatively small landmass. Within birds, the only comparable situation is that of the now extinct elephant birds of Madagascar, where seven species apparently evolved in isolation. In contrast, the classic examples of island evolutionary radiations, such as the Galápagos finches and the Hawaiian honeycreepers, involved species of small body size.

It will be recalled that when moas first arrived on New Zealand they were already flightless and probably of fairly large body size. Subsequent geographic events facilitating evolutionary diversification contributed to modify this basic body plan. This raises the question, How did numerous species of generally similar body plan coexist in an environment in which the diversity of food resources for large flightless birds appears rather limited? Living ratites, except the kiwis, are omnivorous, and so too probably were the moas. New Zealand did not have an especially high plant species diversity and the small vertebrate fauna available as food for ratites was dapauperate.

Some current ecological research suggests that if two closely related species come to share overlapping distributions, and if food resources are limited, then either one of the species will go extinct or the two species will diverge in those aspects of their morphology, behavior, and ecology that are related to resource utilization. If divergence occurs, the species will be able to coexist. In those situations in which many similar species coexist, the problem of dividing up the available resources becomes more acute, and we would predict marked divergence to evolve, presumably to reduce interspecific competitive pressures.

This ecological theory may explain the divergence in body size and bill shape exhibited by the moas. Differences among genera reflect variation in bill shape and body proportions, whereas differences among species of the same genus primarily reflect variation in size. The species in any one location, therefore, apparently manifested a broad range of morphological and, presumably, ecological diversity. Because the stomach contents of some individual moas have been preserved, we know that they fed on leaves, twigs, and fruits.

The striking diversity in bill shape suggests there was a corresponding variety of feeding methods. Compare, for example, the large species *Pachyornis elephantopus*—even its name characterizes this ponderous six-foot bird—with the slightly smaller *Euryapteryx geranoides*. Both were roughly similar in size and occurred together over

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much of South Island. *P. elephantopus* possessed a high, rounded cranium with a long, narrow, pointed bill. Its jaw apparatus was heavily constructed, and the large jaw muscle scars indicate a species capable of crushing or tearing highly resistant foods. On the other hand, *E. geranoides* had a broad, flattened cranium with a short, broad bill rounded at the tip. Although the skull presents an impression of strength, the relatively small jaw muscle scars indicate a more limited ability to crush and tear food. Another species in the same deposits, *Emeus crassus*, was the same size as *Euryapteryx geranoides* but had a jaw mechanism as weak as that found in some much smaller species. This example could be applied to the species assemblage known to occur at any given location.

These observations suggest that the species of moas may have avoided competition for the available food resources because they browsed at different heights in the vegetation and possessed contrasting abilities to harvest foods.

The millions of years of geographic isolation and differentiation, accompanied by the evolution of differences in size and shape, resulted in the presence of approximately fifteen species in geologically recent times. Why then did the moas go extinct, apparently all within the last thousand years?

The answer to the question of moa extinction is complex and has been debated for more than a century by archeologists, biologists, and geologists. The difficulty is that the historical record—whether of natural or archeological deposits—is woefully inadequate. Nevertheless, as more sites are discovered and aged by radiocarbon-dating techniques, our picture of moa history is steadily improving.

The Maori people arrived on New Zealand from eastern Polynesia about a thousand years ago. Archeological evidence reveals that both North and South islands were widely settled by 700 years B.P. Bruce McFadgen, a New Zealand anthropologist, estimates the total population of the colonizers at between 500 and 1,000 individuals, but by the fifteenth century those numbers had grown to somewhere between 10,000 and 100,000.

The first human inhabitants found themselves in a wild and pristine land. A lush forest of mixed podocarp-broadleaf trees covered the subtropical areas of North Island and the west coast of South Island, and an equally dense southern beech forest was distributed widely in mountainous and temperate lowland locales, especially on South Island. These forests made penetration and agricultural exploitation of the island interior extremely difficult and nearly all coastal settlements practiced clearance by fire. McFadgen estimates that after 300 to 500 years of occupation perhaps as much as one-third of the forests had been burned.

The lands and waters of New Zealand offered the Maori colonizers a diversity and abundance of food sources. The ocean and coastal waters had fish, shellfish, and large numbers of the New Zealand fur seal. The forests yielded many kinds of edible plants. There were no native land mammals other than bats, but there were giant birds. One can almost imagine what the first sight of moas must have meant to these colonizers at the end of a journey that had taken them over 1,500 miles of open ocean. And they rapidly took advantage of this readily available food source. Moas were harvested in great numbers. Their bones were broken, probably for the marrow, certainly for their use in making tools, such as fish hooks, and for decorative ornaments. Moa nests were also exploited as a food source, as eggshells are abundant at some sites.

From the frequency of moa bones associated with dated Maori sites, the evidence is fairly clear that large numbers of moas were killed in a short period of time. Hunting of moas was apparently a regional phenomenon, depending upon the local abundance of the birds and other foods. Along the coast, for example, food was gathered primarily from the ocean, and moas were rarely used as a food source. Hunting pressure was more severe on South Island, and this probably reflected the vast differences in climate encountered over the whole of New Zealand. On North Island, as moas and other animals became scarce from overhunting, the Maori shifted from a predominately hunter-gatherer economy to one based on agriculture of the East Polynesian sweet potato and other cultigens. The climate over much of South Island, on the other hand, was too cool to effectively grow many of these plants. Thus, southern Maori populations were forced to rely more on hunting.

Did hunting pressure alone result in the extinction of the moas? This is difficult to say. Certainly, hunting was crucial in many ways. Bones of young birds are frequently found at Maori sites, and the removal of eggs and young would have affected future population numbers much more severely than if the killing had been restricted to adult birds (which may have bred before they were killed). Evidence for a strong effect of hunting is also presented by the large array of other ex-

*Excavation of moa bones at Te Aute Swamp, New Zealand, 1888*

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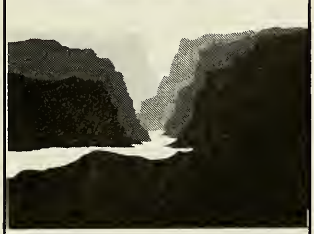

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*Sir Richard Owen with moa bones, 1846*

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tinct species of birds that are commonly found at Maori sites. These included a giant goose, a flightless duck, an eagle, rails, and a crow; one could also add to this list many of the species that are now very rare on the islands. There can be little question that hunting had an impact on virtually the entire avifauna.

But hunting cannot be the only cause of moa extinction. Surely the firing of the forests, with its consequent destruction of thousands of square miles of habitat, had a devastating effect because most of the species of moas were distributed primarily in the lowlands. Apparently, only a few of the smaller species commonly occupied the mountainous regions. A reasonable assumption is that the restriction of moa populations to small tracts of relict forest greatly increased their chances of random extinction.

The species of *Dinornis, Emeus*, and *Pachyornis* were the first to be exterminated, probably within several hundred years after human colonization. *Euryapteryx* was still commonly found between 600 and 800 years B.P., but was extinct by 300 to 400 years B.P. There is no verified record of survival of any moas after this latter date, but some authorities believe that a small species of *Anomalopteryx* or *Megalapteryx* may have survived in the remote wilderness of the Southern Alps until the eighteenth or nineteenth centuries.

*Joel Cracraft is an associate professor of anatomy at the University of Illinois Medical Center.*

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# The Balancing Act of Moose and Wolves

*Stability in a prey population can move from one level of equilibrium to another. But if excessive human exploitation is added to predation pressures, the prey may not recover*

**by Gordon C. Haber**

The moose ranks as one of the most biologically successful of the large northern mammals, having colonized a wide diversity of habitats across both hemispheres and persisting over most of these regions despite sustained exploitation by humans, wolves, and bears. In 1966 I began a long-term wildlife study in Alaska's Denali (Mount McKinley) National Park, in part to learn more about moose behavior and population dynamics in a typical subarctic ecosystem. (The Indians called Mount McKinley, Denali, "The Great One," and the name Denali is still used commonly.) While my emphasis in this research has been directed more at the wolf packs that inhabit the region, the role of the moose as a primary year-round food source for most of the Denali wolves mandates that these two species—and others—be observed as a single interacting unit. Moose are complex, highly tuned creatures largely because of predation pressures, but these same pressures also create a potential for much trickier behavior at the population and system levels than has been recognized until recently.

Like most of Denali's large mammals, moose produce their young in May, the beginning of this region's "biological year." By about the middle of the month, most surviving calves from the previous spring suddenly find their heretofore protective mothers to be extremely aggressive toward them, to the point where the bewildered yearlings must either strike off on their own promptly or be dashed to death by violent attack. Only the yearlings with mothers not pregnant are per-

*With the velvet rubbed from his fully grown antlers, this bull moose appears ready for the rutting period. Beginning in early September, intense sexual activity among adult moose in the Denali region of Alaska lasts about six weeks.*

*During the early rut, one bull approaches another, above, with typical rolling and swaying head motions. When fighting ensues, right, the violent battle often lasts for an hour or more.*

mitted to remain with them. Most of the new calves are born during May. Willow thickets throughout the preferred calving regions yield cows with single calves or twins. My surveys indicate that birth rates generally range from 70 to 125 calves per 100 mature cows.

Wolves and grizzly bears combined normally take a heavy toll of calves during the first month or two following birth, even though a cow moose in good condition defends her young with a ferocity seen in few other northern mammals. Young calves are also subject to heavy nonpredator losses, for example, due to wind chill, drownings during river crossings, and other accidents. Nonetheless, since the annual loss of older moose does not normally exceed about 15 percent of their spring total, only a relative few of the calves that are born need survive for the population to remain stable. It is almost as if the rest are "programmed" to be eaten, insuring sufficient energy transfer into higher trophic levels to support the system's major predators and scavengers.

Apparently more than maternal defense is necessary to guarantee that even a small percentage of calves survives early predation. One of the most important antipredator responses that moose have evolved is the synchronization of births each spring. The short, four- to five-day span during which most calves are born amounts to a "pulse" that may saturate the predators, at least temporarily. During the actual birth process, and sometimes for a few hours afterward, a cow cannot fully defend her one or two calves or herself; with dozens of moose births occurring in close sequence, it is unlikely that wolves and bears could kill and consume as many victims as might be possible were births staggered over a longer time interval.

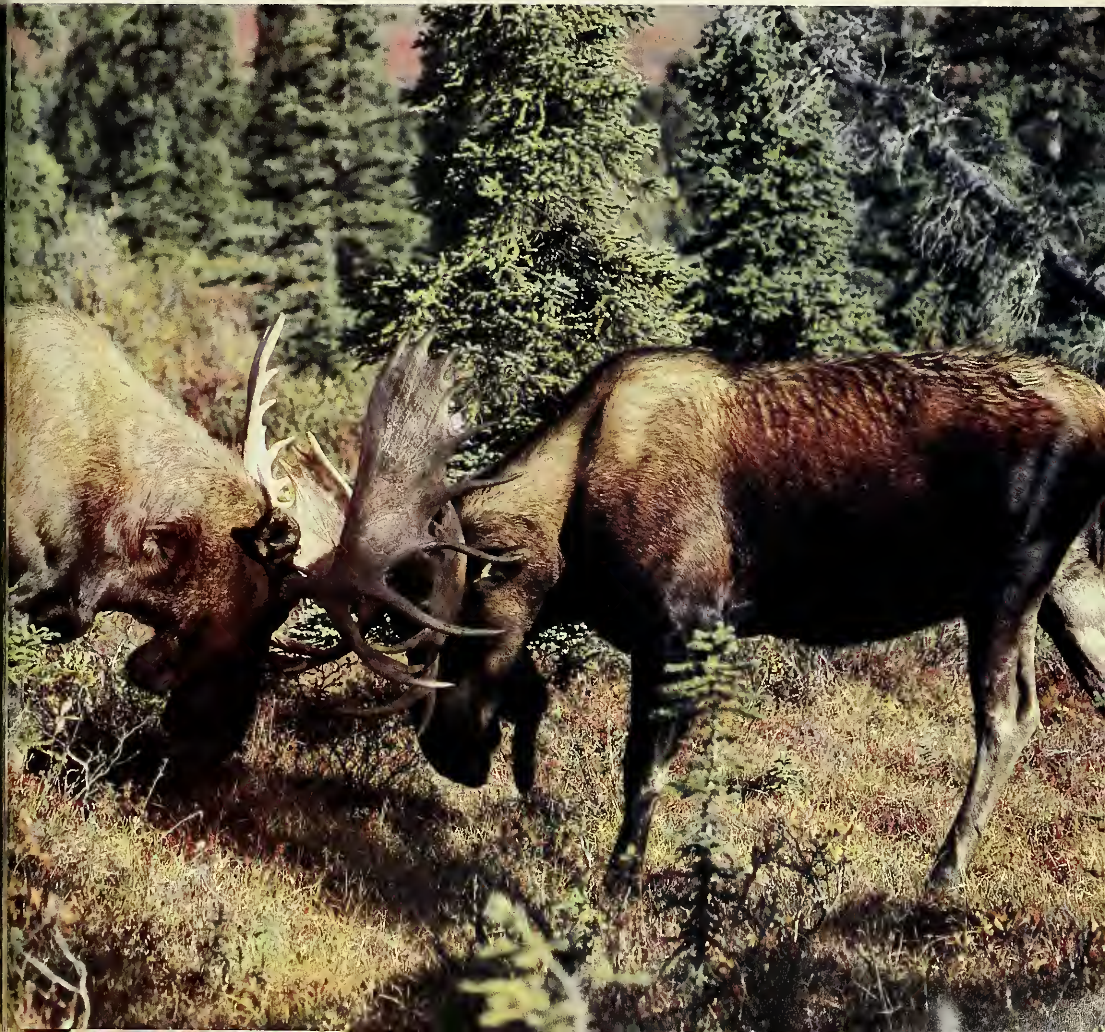
For moose calves that overcome the many early obstacles to survival, still other problems await. The most important of these is shared by all living organisms at arctic and subarctic latitudes: a need to produce biomass rapidly, prior to another winter only three to four months away. Intense solar radiation and long day-length (peaking to about twenty-two hours on June 21) provide major energetic compensation for the brevity of summer, but still one senses an almost urgent race by creatures large and small to develop and prepare. Soon after the Denali tundra fully greens in the first or second week of June, calves are already quite mobile, and nearly weaned, they and their mothers browse lush willow shoots, aspen leaves, and other vegetation for long hours throughout the range. Growth is spectacular. At birth a calf weighs about 30 pounds, a few weeks later perhaps 60 to 70 pounds, and by the end of August approximately 150 to 200 pounds. This compares with late August adult weights on the order of 800 pounds for cows and 1,000 pounds for bulls.

Major changes become evident among the adults as well. Individuals of both sexes begin to develop a dark, shiny coat of guard hairs, replacing their now ragged winter pelage, and body fat reserves are replenished. Perhaps most dramatic is the reappearance in bulls of antlers, which are shed usually by December or January. Six to eight inches of new antler growth can be seen in some bulls by late April, and two to three feet in most mature bulls by July or early August. Antlers are a form of bone, nourished during growth by a characteristic soft covering of skin and blood vessels known as "velvet."

Dark, crisp nights return to Denali by early August. Before the end of the month the hills have been dusted with one or two light snowfalls and the tundra has started to redden slightly. Fall begins in an almost subtle way, but by the end of the first or second week of September, colors explode to a spectacular peak everywhere and the tundra seems ablaze. Coinciding closely with this dramatic seasonal change is an equally dramatic change in moose behavior. This marks the onset of the rut, a period of about a month and a half during which almost every adult in the population becomes involved in intense sexual and breeding activity. To me this is the most interesting phase of the moose population's annual cycle; the willow thickets and spruce patches come alive with action as moose begin to appear in substantially larger numbers than at any other time of the year. By late August many bulls have partially rubbed the velvet from their fully grown antlers; virtually all will be in handsome, polished form a week or two later.

Bulls can now be seen moving about everywhere, challenging each other at first by thrashing their antlers in willow brush, then more and more frequently during light sparring matches. Soon adults of both sexes begin congregating in the same areas, bulls pursuing the cows. Many of the cows are drawn by assorted vocal and olfactory enticements offered by the bulls. Rutting behavior itself is important in this regard: a mature bull thoroughly paws up an area of ground, urinates and ejaculates repeatedly over the spot, and then paws it up again, often continuing this behavior for an hour or more. On numerous occasions I have watched an adult cow a half mile or more away come running and squealing to the resultant wallow as if half crazed, then roll excitedly in it over and over again.

Within a week or two many bulls have assembled harems through such behavior, and by the end of September it is not uncommon to see ten to twenty cows with a single large bull. Often two or more groups form almost adjacent to each other; there are several locations in Denali where each fall as many as fifty to a hundred moose gather in an area of less than five square miles. It is a busy time for the largest, dominant bulls, for they



constantly shepherd their cows and must meet continuing challenges from bulls without cows. While aggression at this time seems to build to higher levels of intensity among the bulls, there are also frequent hoof-lashing battles between cows, suggesting that many of them compete for a bull's attention even after secured within a harem.

When a cowless bull approaches a harem he may remain near the periphery for a few hours or a day or two, but then comes the inevitable confrontation. A typical threat sequence by the bull in possession usually suffices if he is the larger of the two: he thrashes his antlers in brush, then begins walking steadily toward the intruder while rocking his head and antlers slowly and rhythmically in a side-to-side arc, issuing low coughing grunts, and flicking his tongue back and forth over his lips. If this does not convey his message adequately, the bull in possession may bolt for the other bull in lightninglike, ten- to fifteen-foot leaps. This action usually convinces the intruder to try his luck with another harem. In cases where the challenging bull is about the same size or larger, a violent battle often follows the threat displays. This is an awesome spectacle, with the two huge beasts repeatedly crashing into each other, often for an hour or more. Commonly, such battles end with both bulls flattened in total exhaustion amidst hundreds of square yards of torn-up ground and uprooted brush and small trees.

The intense rutting competition helps insure that prime bulls do most of the breeding; however, the high energy costs render many of them more vulnerable to predators and other mortality agents. During the rut practically every mature bull is drenched in sweat from the almost constant activity; and since bulls spend relatively little time eating, their substantially depleted body fat reserves cannot be fully rebuilt before winter. This may lead to heavier adult bull (versus cow) losses during the ensuing winter, but the difference is evident even before the rutting period ends. Some bulls are killed outright in the thunderous battles over harems. More commonly, wolves and grizzly bears deal the final blow. My observations indicate that these predators learn the best locations for moose rutting activities and hence encounter weakened bulls more often than would be expected on the basis of chance alone—similar to what occurs during the spring calving period. (Moose in the Denali region focus their calving and rutting activities in different areas, but in each case these appear to have remained traditional for many decades.) If a wolf pack or a bear arrives just after two bulls have fought to exhaustion, a double kill becomes very likely. I observed this result in five instances during my fall moose surveys.

The tundra turns brown by late September, and shortly afterward the first snowfalls have crept down the mountainsides to the valley floors. Mating activity reaches a peak at about this time, then during the next few weeks social calm begins to return as individuals disperse from the rutting groups. Now the task is basic and straightforward for all sex and age classes: survive five to six months of severe cold, deep snows, fewer opportunities to find adequate browse (which itself is of lower nutritive value than in the summer), and continued pressure from wolves.

The physical condition of virtually every moose in the population deteriorates during the winter, but the slide is much steeper and the odds of surviving until spring are much lower for some, especially for individuals already at a disadvantage because of age, injury, lower fat reserves, or other debilitating factors. Surprisingly though, any calf that has managed to stay alive through the fall apparently enjoys good odds of surviving its first winter. The sex and age data I secured in my annual population surveys indicate that about 60 to 90 percent of the calves that die between birth and sixteen months of age die within the first four months, and most of these deaths occur during the first month and a half. In short, calves still alive when winter begins have already successfully endured much testing, and no doubt most were born in good condition to the strongest and most experienced mothers.

As winter progresses and the snow deepens, developing one or more crusts, moose are forced to expend larger amounts of energy in search of forage that is increasingly difficult to find. Wolves begin to enjoy better hunting success, killing 8 to 9 percent of the moose they encounter in a very severe (deep snow) winter, compared to only about 2 to 3 percent in a mild winter and 5 to 6 percent in an average winter. Moose deaths from nonpredatory factors also increase; in certain years wolves feed heavily on these winter kills, which reduces the number of live animals they kill. Winter can also exert residual impacts on the moose population, for example, through greater nutritional stress in pregnant females. Spring birth rates in Denali are approximately halved after a severe winter.

One of the major ways in which moose minimize such impacts is to migrate. Moose migrations in Denali rarely exceed fifteen miles or an elevation change of 1,000 feet, but when a deep-snow winter hits (as in 1970/71, which was a record for this region), this degree of shifting is sufficient to remove the population from ranges where normal movements and foraging activities can become extremely difficult. The timing and extent of each winter's migration appears to be keyed to average snow depths on the summer ranges. If there is less than one and a half to two feet of snow on these ranges, little or no migration occurs. As depths begin to exceed this threshold, about one-third to one-half of the population moves, and by the

*A bull moose, left, checks a cow's sexual receptivity by smelling her. Five cows, below, flock around the large bull, which has collected them as part of his harem during the rut.*

*A cow, above, nurses her twin calves at the edge of a pond. Weighing about 30 pounds at birth in the spring, the calves grow rapidly. By the end of August they will weigh between 150 to 200 pounds.*

time the average reaches three to four feet, essentially all have left for the winter ranges.

Moose that have migrated are normally able to return to the summer ranges by late April or early May, prior to calving two to three weeks later. Many of the pregnant cows bear their calves in very specific and traditional areas within the summer ranges; one cow that I could identify produced her calves within 100 yards of the same location for at least three years during my study. Not surprisingly, wolves traditionally produce their young in these same areas, using nursery dens at least several decades old.

The lingering deep snow of a severe winter may prevent most moose from returning to the usual calving areas before mid to late May, leading to an important change by the wolves too. This happened in spring 1971, and the result for the moose was a form of compensatory relief from predation. I observed the wolves closely while they scouted the major calving areas in late April and early May 1971, cleaning out established dens and hunting near each for several days, but there were few contacts with moose. The pack finally departed on May 10 and ended up committing itself to a den in another area, closer to an active caribou migration route. Over the next two weeks most of the moose were able to return to their usual calving areas, where cows produced young at about half the rate seen in other years (the low birth rate was predictable because of the impact of the preceding record winter on pregnant cows). Yet there was actually a higher spring to fall rate of calf survival than in summers following winters of average or even mild severity. The higher summer 1971 survival rate could be attributed in part to the likelihood that the severe winter prevented many weak, inexperienced cows from bearing calves. But the wolf denning shift also had much to do with this by, in effect, exposing moose calves to far less wolf hunting than in other summers. Apparently, the lingering deep snow and delayed moose return influenced grizzly bears in some similar manner for I noted less hunting in the calving area by this predator as well.

Perhaps the most significant observation to be made about moose in Denali relates to the long-term status of the population. For the past fifteen years and probably for at least forty to fifty, the total number of moose has remained relatively stable despite substantial predation by wolves and bears and much variation in levels of winter severity. The best moose habitat and highest concentrations of moose are found within the 600-square-mile territory of one wolf pack in particular, and predictably, moose

are used heavily by this pack on a year-round basis. Mountain sheep and to a lesser extent caribou are supplementary food items. Moose distribution is patchy (nonrandom) and moose migrate seasonally from one portion of the territory to another, yet based on population surveys undertaken by myself and National Park Service biologists, the territory-wide density (number of moose per 600 square miles) has fluctuated from only about 0.7 to 1.4 moose per square mile. It might be tempting to relate this stability to habitat factors, given the slow rate of successional change seen here (typical of subarctic ecosystems) and the virtual absence of fire disruption. Nevertheless, we know that this population enjoys a high reproductive rate and that in general the individuals are in excellent physical condition, contrary to what is observed for most ungulate species that

*Followed by her calves, a cow chases a yearling from the area. Until the spring calving season, female moose are protective toward their young of the previous year, but now their attention must focus on the newborn offspring.*

reach the maximum carrying capacity of their habitats and are directly limited by food supply. Furthermore, despite some predictable localized overbrowsing, the Denali population does not appear to be suffering any widespread shortage of food vegetation.

I recognized from the outset that it would be simplistic to assume that only one or a few factors were responsible for the observed population stability, although it seemed likely that predation played a central role. To examine this question in detail, my colleagues at the University of British Columbia and I decided to use a systems approach, in which we considered several hundred interacting predator, prey, habitat, and environmental variables jointly. This meant we would need some sophisticated bookkeeping, hence we began by organizing the many bits and pieces of field data into a computer simulation model. We were then able to integrate all of the variables into only two basic components of system change: moose net production (births minus nonpredator losses) and losses due to predation, and to consider these as a function of prey (moose) density. Next we translated the results of this analysis into a simple graphical model, known as a recruitment curve, which showed variations in the moose population's net annual increment (the difference between the production and loss components) over a wide range of moose densities.

This indicated that increments are positive at moderate moose densities (net production exceeds predation losses), but that they decrease to negative values at both high and low densities. At densities where a positive/negative change occurs the increment is equal to zero, and hence there is a potential equilibrium. We identified three possible equilibria: one within the range of densities observed in Denali over recent years, another at a much lower density, and a third between these two but closer to the lower one. Both the upper and middle equilibria appear to be generated in about the same way. Moose net production drops sharply at each of these densities, but predation losses do not decline in a corresponding way; thus pre-

*Ears back and hairs bristling, a cow charges through a tundra pond toward the photographer. Sensing a threat to her calf, the enraged mother can be very dangerous.*

dation exerts a much greater impact, and in each case a point is reached where it completely removes and then exceeds the equivalence of annual net production. The downturn in net production at high density is probably due to greater resource competition, leading to fewer births and more nonpredator deaths. At the middle equilibrium this results from a sharp drop in births due to the much smaller adult population (that is, fewer cows). The lowest of the three equilibria appears to exist because of a learning-related phenomenon referred to as "switching." In a multi-prey system a predator such as the wolf searches much less for a particular prey type when it becomes so scarce that it is difficult to find. This allows the prey to begin an increase, whereupon the predator is again able to hunt it to advantage, until depressing it to the switching-off point once more, and so forth.

Under natural circumstances a subarctic moose population subjected to wolf predation could be expected to fluctuate about the upper equilibrium for a long period, probably for decades at least. As random events pushed the population below this equilibrium into the density range where increments are positive, it would simply increase again. On the other hand, if pushed somewhat above the equilibrium (for example, by immigration), the negative increments corresponding to this density range would produce a population decrease. In other words, the population is anything but delicately balanced at a stable size. It fluctuates considerably, but the important point is that it can absorb much stress and still continue to fluctuate about the *same* density.

I observed a dramatic illustration of this resilience during my fieldwork in Denali. Within a period of only six years the region experienced a virtually complete spectrum of winter variability, based on the existing fifty years of weather data—the most severe winter ever recorded (1970/71), a second severe winter (1971/72), one of the mildest (1969/70), and several average winters. Winter conditions can exert a variety of direct and indirect impacts on moose birth and death rates, thereby influencing total numbers, yet there has been no major shift in the equilibrium density about which this population fluctuates. Perhaps most impressive of all, my surveys in fall 1970 and 1971—before and after the very severe winter of 1970/71—indicated there had been a net decrease of only 8 to 10 percent in the number of moose present.

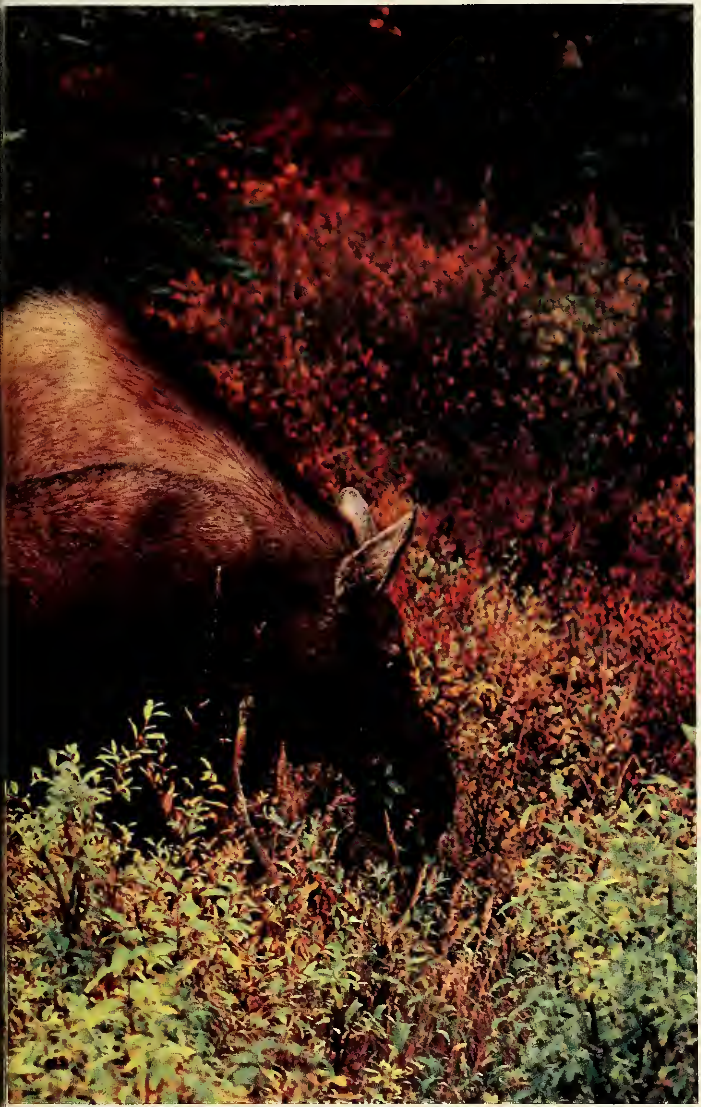
Suppose, however, that the population is subjected to a series of impacts even greater than what has been observed to date, so that it eventually decreases to a density just below the middle equilibrium. Since the combination of lower net production and proportionately heavier predation below this threshold results in negative net annual increments, the population begins a rapid decline that continues even after the initial disturbing agent is removed. With no human intervention (predator control, for example), the decline would deepen until finally abated at a very low equilibrium by

*A spike bull and a cow browse amidst the colorful foliage of mid-September. The bull may be a yearling of the female, which tolerates his presence because she did not bear calves in the spring.*

predator switching. Even in a multi-prey system it might then take twenty to thirty years for the wolves to emigrate or starve to the point where recovery could begin.

This sequence could be triggered by emigration, heavy mortality, and/or reduced natality associated with a natural disturbance, such as a major flood or fire, or perhaps a winter much harsher than 1970/71. Most ecosystems, however, have been resilient to all but the uncommonly severe natural disturbances; were this not the case, the subarctic mountains and tundra would have plunged into biological disarray and scarcity centuries ago.

A more likely trigger in today's North is excessive moose hunting by humans, an impact that we were able to simulate easily in our model. The mechanisms revealed to us in this analysis turned out to be much more subtle than I had expected. Hunting removes a portion of each year's net increment from the moose population, but most important we found that this leads to two equilibrium changes: the upper equilibrium shifts to a lower density and the middle equilibrium shifts to a higher density. As a result, the moose population begins to fluctuate over a lower range of densities and within narrower constraints. Moreover, since increments are negative below the middle equilibrium and this now occurs at a higher density, the odds of an irreversible decline are increased. This means that the same above-average winter that earlier caused only a minor decrease in numbers now could easily lead to a major decline, although it is important to emphasize that such a decline would be expected only when the population is subjected to excessive hunting, specifically an annual rate greater than 6 to 7 percent, according to our analysis. Furthermore, to sustain this harvest the population would first have to be reduced to 60 to 70 percent of its upper equilibrium density, to the level corresponding to maximum net production (at the upper equilibrium net production is lower and just equals the predation loss).



The foregoing multiple equilibria pattern is not unique to moose–wolf systems. Ecologists have found that a wide variety of natural systems are capable of "flipping" abruptly between different stability regions—some regularly, others only when heavily stressed. This phenomenon appears to extend to many physical, socioeconomic, and human behavior systems as well, and to better describe it, mathematicians have even developed a new language, referred to as catastrophe theory.

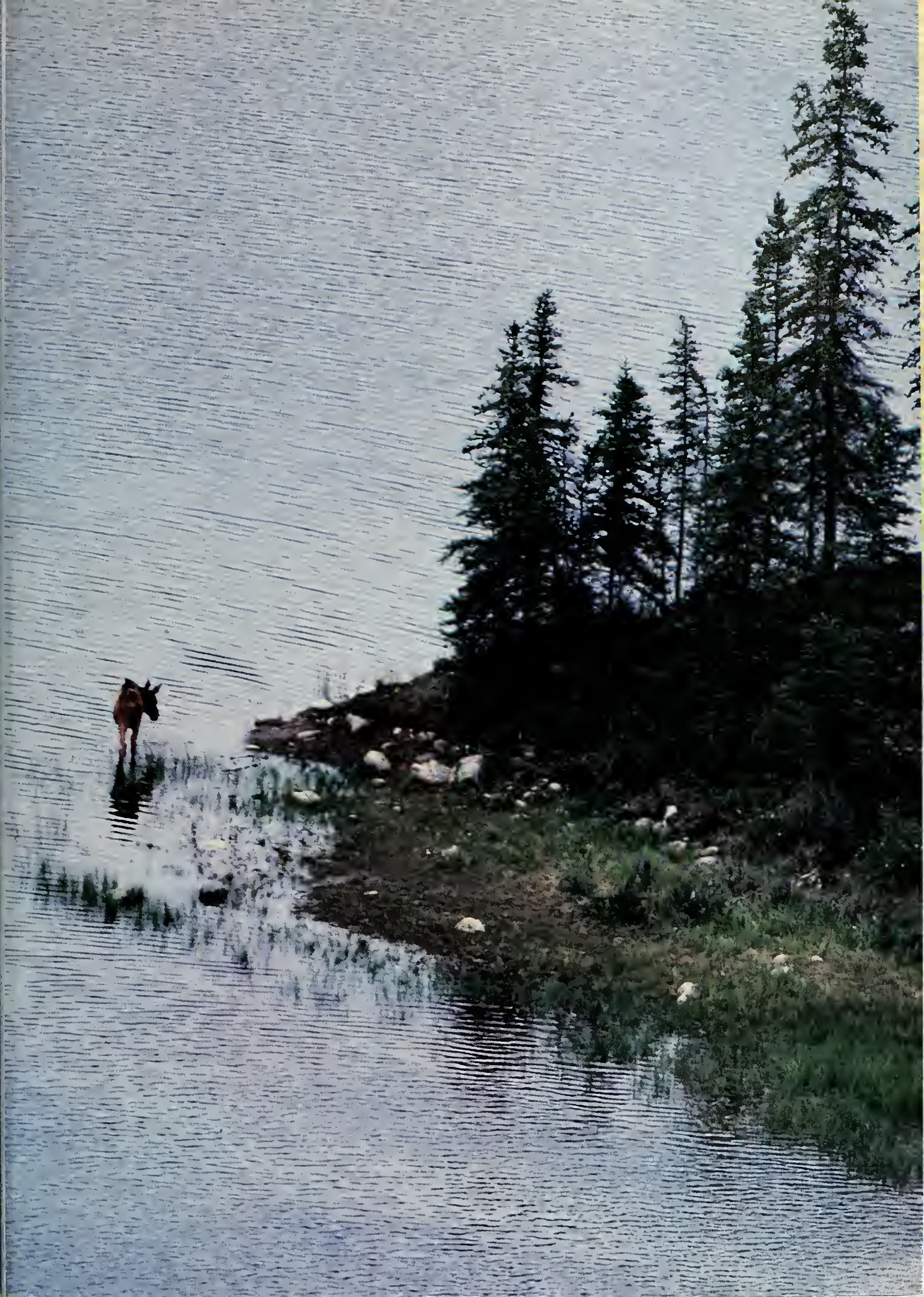
The multiple equilibria/catastrophe theory viewpoint suggests that moose and wolves interact much the same way as, for example, do the parts of a suspension bridge. A wolf pack, its prey, habitat, and assorted environmental factors jointly compose a system; the interconnected beams, supports, and cables of a bridge also compose a system. Normally the bridge is in a horizontal position, at an upper equilibrium, but add weight in the center and it begins to sag a little. Add a bit more weight and the bridge sags a little more, in a manner roughly proportionate to the additional weight. Then remove all the weights and it returns to its previous position. Now add the same weight increments again, but this time many more of them. A threshold will be reached—analogous to the moose population's middle equilibrium—beyond which the addition of just a bit more weight results in a proportionately much greater system change: the bridge suddenly buckles to a completely different position, analogous to the moose population's lower equilibrium. No longer is it possible to restore the bridge to its original position by simply removing the weights. Originally, neither the moose–wolf system nor the bridge was so delicately balanced that it could sustain no additional stress at all. The moose population continued to fluctuate about the same equilibrium even though subjected to the extra "load" of variable winters and some hunting by humans (that is, 6 to 7 percent). Likewise the bridge was resilient to extra stress, flexing somewhat under each additional bit of load, yet still maintaining about the same position. But once a critical threshold was exceeded, both systems shifted catastrophically to another stability region centered on a completely different equilibrium.

The apparent functional similarity that the multiple equilibria/catastrophe viewpoint reveals for a wide variety of systems suggests that they can be understood more easily than we have assumed. In other words, we may not need to reinvent the wheel each time we seek to determine why nature behaves as observed. The same conceptual framework might suffice whether the system we are attempting to understand comprises moose and wolves, mice and owls, or cables, beams, and supports. On the other hand, their characteristic discontinuities and abrupt changes require that much caution be exercised when and where we choose to exploit these systems. Moose can be harvested from a moose–wolf system at an annual rate of about 6 to 7 percent, but if the rate is increased by only a few percentage points, moose numbers may suddenly begin a decline to such low levels that the sustainable yield decreases to almost nothing and controversial predator-control measures are then demanded. Caution is also needed in harvesting other ungulates inhabiting the region. If the wolves utilize a second prey species, such as sheep, as an important food supplement and this population is overharvested to an unusually low level, there will almost certainly be more predation on the moose, leading to an equilibrium shift similar to what was described earlier and hence less resilience to both natural and human disturbances.

Nor does the potential for trickery end even here. An imbalanced adult sex ratio appears to be characteristic of most subarctic moose populations under natural conditions. Within the Denali wolf pack territories that I monitored, the ratio ranged from about 35 to 75 adult bull moose per 100 adult cows. In areas where exploitation is permitted and takes the form of bull-only harvests, ratios as low as 5 to 10 bulls per 100 cows have been recorded. Various studies have shown that such abnormally low ratios do not necessarily lead to reduced pregnancy rates. However, we know very little about the possibility of other impacts on recruitment. For example, with so few bulls it probably takes longer for the same number of cows to be inseminated during the fall rut, which could mean less of a birth pulse in the spring. If births are staggered over a longer time interval, there could well be less predator saturation and, consequently, higher mortality of young calves. Moreover, later births as a result of delayed breeding might mean that many calves enter their first winter at a survival disadvantage, because of less opportunity to develop physically beforehand. A difference of even a week or two could be critical in this regard, given the rapid rate at which early growth normally occurs and its close synchronization with the short interval of high productivity in browse vegetation each summer.

Moose are an important resource to human users throughout the North, especially in Alaska, but over the past ten to fifteen years subsistence and sport-hunting demands have increased to the point where serious population declines have occurred in at least several large regions. When this happens, both the resource and its users lose in a variety of ways. From a strictly biological viewpoint clearly some exploitation is acceptable. The challenge that remains is to apply our growing knowledge about moose behavior and interactions at the system level to help insure that exploitation does not exceed critical limits. □

*Calves may wander some distance from their mothers at times. In the Denali region, 60 to 90 percent of the calves that die between birth and sixteen months of age perish within the first four months.*



# The Versatile Opium Poppy

*Nonnarcotic byproducts of this cash crop are traditionally important resources for Turkish villagers*

**Text and photographs by**
**Jacques Bordaz and Louise Alpers Bordaz**

Opium and opium derivatives have been valued since antiquity for their therapeutic properties. Unfortunately, these same substances are a major threat to the individual and society because they can induce highly destructive psychic and physical dependencies. During the past ten years, our archeological fieldwork in an opium-producing region of south-central Turkey exposed us directly to an intricate problem that has occupied both international agencies and individual states throughout the twentieth century; that is, insuring an adequate supply of opium for medicinal purposes while preventing the illicit production of, and trade in, opiates that ultimately lead to drug abuse. Our life during the excavation seasons in Gölkaşı village on Lake Beyşehir also introduced us, unexpectedly, to the generally unknown but economically important utilization of the poppy plant for many purposes other than the extraction of opium.

Until 1971, our observations of opium poppy exploitation in Gölkaşı had only been minimal. The object of our archeological research was the site of Erbaba, an early sixth millennium B.C. Neolithic settlement, and our supplemental investigations into the traditional subsistence patterns of the present-day farmers had concentrated on the food plants excavated there—wheat, barley, lentils, and peas. But with the total ban on opium poppy cultivation imposed by the Turkish government on June 29, 1971, we were made acutely aware of this crop by the villagers whose lives we shared during the summer. During these past years, we have witnessed the disruption created by the ban and the impact of its repeal in 1974, and have explored the many facets of the controversial poppy.

To the village cultivator, the injunction against the annual planting of the opium poppy represented the loss of a profitable cash crop. Worldwide pharmaceutical needs had long provided a reliable market for Turkish opium. Furthermore, since the poppy's sowing and harvesting seasons generally precede those of grains, the Gölkaşı farmer had been free to grow these foodstuffs central to the local diet.

A member of the diverse and decorative Papaveraceae family, the opium poppy, which probably originated in the Mediterranean or Southwest Asia, is classified botanically as *Papaver somniferum Linnaeus.* In Turkish this plant is *haşhaş* (pronounced "hash-hash"), not to be confused with *haşiş* ("hashish"), a preparation based on hemp, *Cannabis sativa Linnaeus.* The common red poppy, sometimes referred to as the Flanders or American Legion poppy, is also a species of the *Papaver* genus (*P. rhoeas*) but does not produce opium. Opium, *afyon* in Turkish, is a juice secreted by the maturing *P. somniferum L.* Although concentrated in the capsule, or seedpod, of the plant, this liquid also occurs to a lesser degree within the stalks and the leaves.

Prior to the 1971 ban, the villagers of Gölkaşı had harvested their opium according to a technique widespread in traditional cultures and already documented in the writings of Greek and Roman naturalists. This procedure involved incising the capsule in order to free the trapped secretion. In cold temperate climates, like that of south-central Turkey, the opium poppy is generally planted in the au-

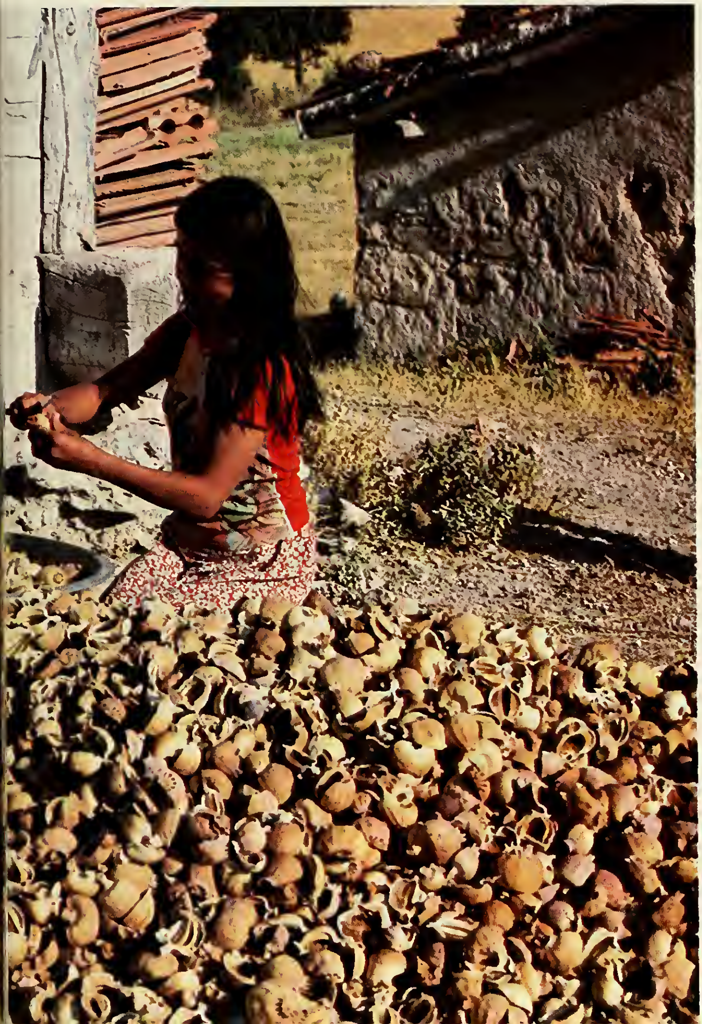
*An opium poppy plant, above, bears buds alongside the maturing seed capsules, from which the flower petals have already fallen. When mature, the dry capsules are collected and split, right.*

tumn. In Gölkaşı, situated at a height of 3,600 feet within a broad basin of the western Taurus Mountains, the spring flowering takes place by late May or early June. The multicolored fields are in bloom for only four to five days, and some two weeks later the plants have ripened sufficiently for the ancient lancing process. In this method, practiced until the ban, several disconnected horizontal incisions were made around the circumference of the capsule. The juice from the capsule proper, in conjunction with that drawn upward by capillary action from the stem and leaves, oozed out onto the surface along the slits and was left to dry for approximately eight to fourteen hours. This raw opium was then scraped off and, when sufficiently coagulated, formed into balls or cakes destined for the Turkish Soil Products Office. The poppy plant, its continued life assured by the cautious, discontinuous incision of the capsule, remained in the field until full maturation.

Although efficient, the incision method involved security risks, since the raw opium collected in the harvest was a potentially harmful drug and also the source of other derivative narcotics. Recognizing the dangers of an illicit traffic in this commodity, the Turkish government had gradually reduced the number of opium-producing provinces, from forty-two out of sixty-seven in 1940 to seven by 1970. The total moratorium in 1971 represented an even more drastic action, one strongly encouraged by the United States. Nevertheless, after several years of successful enforcement, the ban was repealed on July 1, 1974.

The decision to reinstate cultivation of the opium poppy permitted Turkey to participate once more in the lucrative international pharmaceutical market, which had expanded as a result of increasing world health care and was suffering a shortage of opiates during the ban. Despite attempts in the past thirty years to synthesize equivalent drugs, modern medicine still relies almost exclusively on natural products of the opium poppy for the treatment of certain widespread problems. Codeine, a highly effective cough suppressant and analgesic, is one of the most common medications. Present in opium in small amounts, this alkaloid is today primarily extracted in a secondary process from the main opium alkaloid, morphine. Of the morphine employed by the pharmaceutical industry, more than 90 percent is at present transformed into codeine. The use of morphine proper, a potent pain killer and sedative, has been curtailed in recent years because it is intensely habit forming, and heroin, a morphine derivative, has actually been outlawed in most countries because of its even more dangerous addictive properties. Raw opium, now completely supplanted as a therapeutic drug, was used extensively before methods of extracting its alkaloids were developed during the nineteenth century. Enduring quasi-medical uses of opium, documented as early as classical times, are now held responsible for the long history of abuse by eating, infusions, and smoking that marked opium as the object of the earliest international campaigns for drug control—by the Shanghai Opium Commission in 1909 and The Hague Convention in 1912.

In the autumn of 1974, the Gölkası cultivators and their compatriots in the seven authorized provinces planted the opium poppy once again in preparation for the 1975 crop. Harvests from this time on, however, were to differ in an important way from the ancient practices previously employed. The Turkish government, in cooperation with the United Nations Division of Narcotic Drugs, had resolved to eliminate collection by incision and introduce in its place the "poppy straw" process. Developed in 1926 by the Hungarian Janos von Kabay and adopted thereafter in Eastern Europe, this method bypasses the opium stage entirely and derives morphine directly from the dried plant. Forbidden to lance the capsules, the farmers allow the poppy to mature fully in the field. Harvesting now consists of snapping off whole dry capsules near the top of the stems and removing the seeds before selling the capsules to the Turkish Soil Products Office. Seed collection is restricted to longitudinal splitting designed to provide proof that no horizontal scoring for the purpose of opium retrieval has taken place. Since alkaloid extraction from dried capsules is a complex industrial procedure, the poppy straw process itself constitutes a system of control. Supplementary security measures were also instituted in 1974, including compulsory licensing, limitation of crop size per cultivator, and extensive surveillance by law enforcement agencies.



The Gölkaşı villagers readily accepted these new techniques and restrictions. Eliminating opium production did not affect them adversely since the use of opium in folk remedies had disappeared with the proliferation of well-stocked modern pharmacies in the region. Nor had they indulged in opium for pleasure. In Gölkaşı, as elsewhere in Turkey, strict mores against opium consumption for other than therapeutic reasons have long characterized the rural society. Furthermore, the poppy straw method was immediately recognized as a far less tedious and time-consuming alternative to the lancing practice.

One unexpected advantage of the poppy straw process did not become apparent until the first harvest in 1975. Since the seed yield from unincised capsules is markedly greater, the cultivators profited additionally from the increase in this resource. Although we had in previous years often enjoyed the delicate, nutty taste of the seeds—freshly removed from their capsules or mixed with boiled wheat in a celebration of the new harvest —we were then uninformed of the important role they play in the village economy. Not until the ban did we begin to learn of the extensive exploitation of the opium poppy for nonnarcotic purposes based on the stalks as well as the seeds. Deprived of a major crop during a period of escalating inflation, the farmers at that time had spoken repeatedly of the difficulties they experienced in obtaining adequate substitutes for some of these poppy products, products that again became available with the renewed cultivation.

The seeds (also referred to as *haşhaş*) appear frequently in the local cuisine, especially in those dishes eaten during the long autumn and winter months. For example, dry-roasted and then ground in a mortar, they serve as a topping for boiled whole wheat kernels or embellish certain leavened village breads and biscuits cooked over an open fire. *Börek*, unsweetened filled pastries of almost infinite variety encountered throughout Turkey, acquire a distinctive character in poppy-growing districts such as Gölkaşı. The ground seeds are either kneaded into the dough or, in combination with such ingredients as white cheese, cured meats, and herbs, constitute part of the stuffing. The dessert *baklava*, well known in its more standard versions, benefits similarly from this resource where available. As a highly prized flavoring agent, the seeds of the opium poppy have become associated with treasured regional specialties. In the tradition of village hospitality, these delicacies—such as the sweet prepared from poppy seeds and *pekmez* (grape molasses)—are often prepared for the honored guest.

If poppy seeds in cooking represent a source of domestic pride, the oil extracted from them is a commodity of real monetary significance. After setting aside a relatively small amount of the yield for kitchen use and the next planting, the Gölkaşı farmers bring the remaining seeds to a small mill in the nearby town of Beyşehir, where the heavy, sweet, nutty oil is extracted. According to the present governmental policy, each licensed family may be authorized to cultivate up to 2.5 decares (0.6 acres). With a maximum average crop of about 550 pounds of seeds per field, the poppy oil obtained is some 220 pounds. This quantity is usually sufficient to meet or at least markedly supplement a family's yearly need for cooking oil, a very expensive and sometimes unavailable market product. After all their oil has been extracted, the pressed seeds are not discarded but formed into cakes of protein-rich cattle feed.

High in polyunsaturated fatty acids and slow to turn rancid, unrefined poppy seed oil is used by the villagers primarily in meat and vegetable dishes. Its pronounced but pleasant taste is not considered suitable for the many regional salads, which, we have been told, include a spring salad of fresh poppy leaves picked before the flowering of the plant. Poppy seed oil was once exploited for far more diverse purposes. In rural areas, it served as a nontoxic oil for lighting, and industrially, it provided a base for varnish, paint, perfumes, soap, and medicinal emulsions. Given the limitation of opium poppy cultivation in Turkey during the past forty years and the recent decline in world demand, which resulted in a 50 percent reduction in land under cultivation in 1978–79, such subsidiary uses have vastly decreased.

With the poppy straw method, the capsules—emptied of their seeds—are delivered by the farmers to provisional government purchasing centers. The

*The edible, oil-rich seeds, below, are removed through a longitudinal cut; and the empty capsules, right, are sold to government agents, who ship the harvest to pharmaceutical factories.*

yearly price, calculated generously in order to encourage strict observance of the law, is nevertheless commensurate with other crops so as not to attract new cultivators. To date, the capsules have necessarily been shipped outside of Turkey for the final processing into morphine and codeine. However, an alkaloid factory in Bolvadin, some 80 miles to the northwest of Beyşehir, has been designed to meet all domestic as well as export requirements and should be operating by the end of 1980.

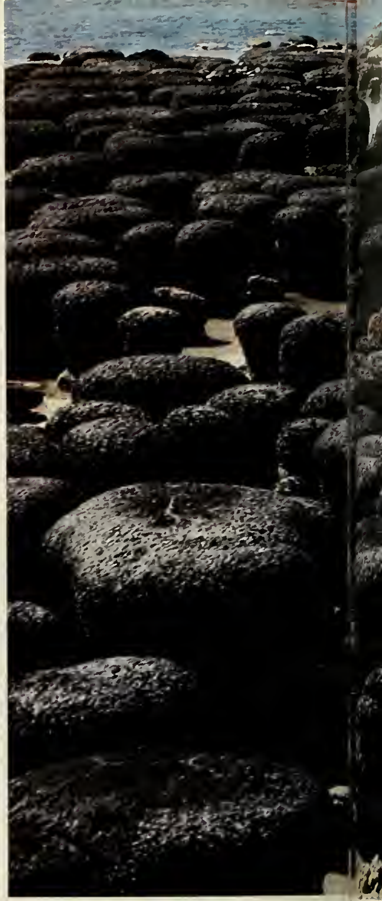
The use of the opium poppy plant is not restricted to the products of the capsule and its seeds. The dry stalks, headless after the capsule collection, are uprooted and transported back to the village where they serve as animal litter and, more important, fuel. The opium-growing regions of Turkey, concentrated on the Anatolian plateau, are generally very poor in timber. A pollen core extracted at the southern end of Lake Beyşehir by paleobotanist Willem van Zeist of the University of Groningen, the Netherlands, reveals that the deforestation of this area was already under way by at least 4500 B.C. An effect of land clearance by early agriculturists, the present-day treeless landscape is the end result of continuous and relatively dense habitation of the Beyşehir basin over some eight millenniums. The Gölkaşı farmers have begun to reverse the denuded conditions by planting poplar and fruit trees in their gardens, but these are rarely employed as firewood. For fuel, the villagers must depend on dung cakes, costly coal and bottled gas, or the poppy stalks. The clean-burning stalks, a highly valued final bounty of the opium poppy harvest, help meet another essential domestic need.

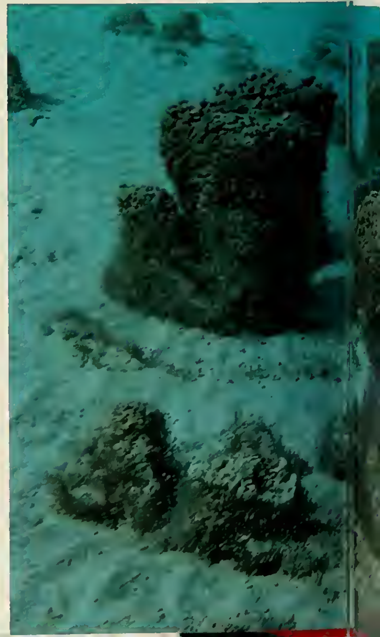
Our long-range, if initially unintentional, investigations into opium poppy cultivation end at present on an auspicious note. The United Nations Commission on Narcotic Drugs has, in its yearly reviews since the 1975 harvest, cited the current success of the Turkish program in preventing illicit opium production while contributing to the world's medicinal needs. Furthermore, implementation of the poppy straw process, by reducing the labor input and amplifying the seed yield, represents a rare perpetuation and even enhancement of ancient lifeways by modern technology. ☐

# Australia's Stromatolite Stronghold

*An uncommon blue-green algal structure, once widely distributed, thrives in water unfavorable to most marine herbivores*

**Text and photographs by Phillip E. Playford**





Twenty-five years ago, a party of oil company geologists discovered that a shallow embayment on the western coast of Australia was home to algal stromatolites, living examples of the oldest megascopic life forms known from the fossil record. Organosedimentary structures built by blue-green algae, or cyanobacteria, stromatolites were widely distributed during the Precambrian period, more than 600 million years ago, and are indeed the most common fossils found in strata of that period. Recorded in rocks up to 3.5 billion years old, in the Pilbara region of Western Australia, stromatolites reached the acme of their development during the late Precambrian. They began to decline markedly early in the succeeding Paleozoic era, at the time of the first great expansion of marine animal life, and this decline has continued to the present, so that algal stromatolites are now uncommon in the world's oceans.

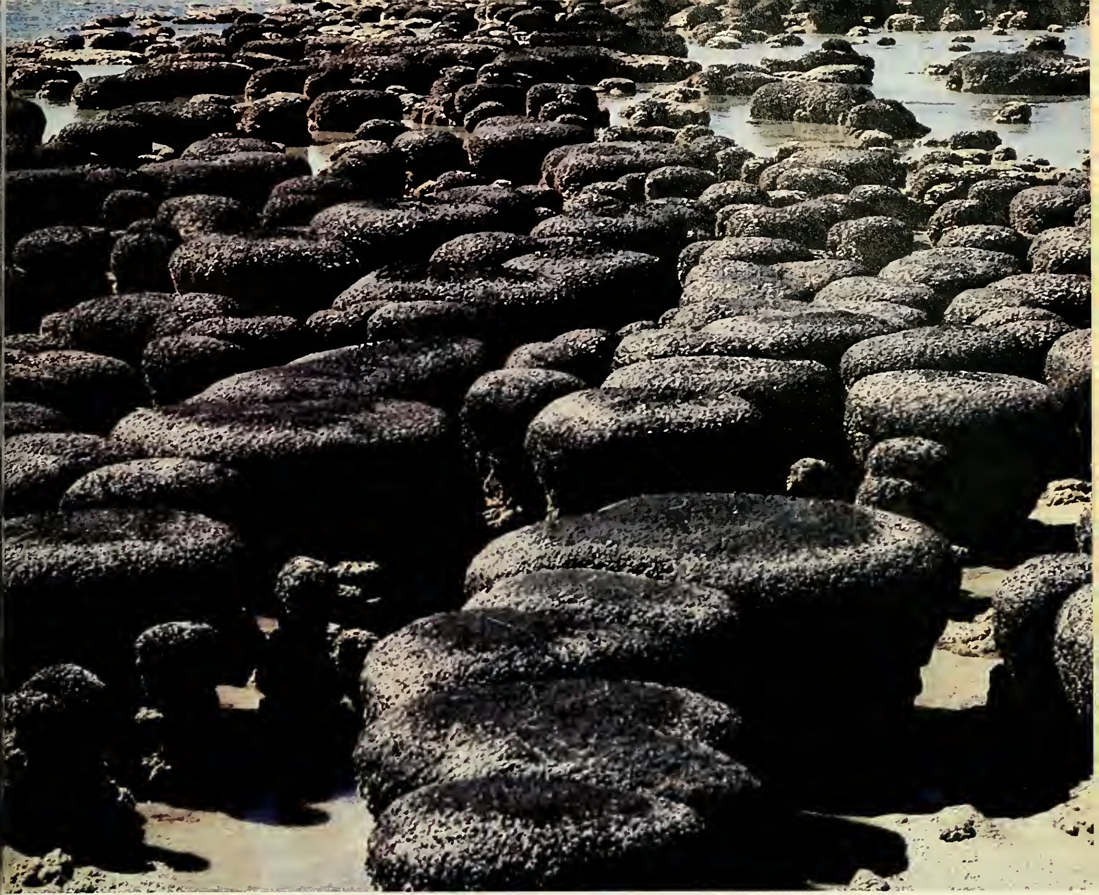
Their principal remaining stronghold is Hamelin Pool, which forms the southeastern arm of Shark Bay, 500 miles north of Perth in Western Australia. The algal stromatolites growing there are the most diverse and abundant known from modern seas. Geologists and biologists have studied Hamelin Pool and its stromatolites to determine the conditions that make this area favorable to the formation of these structures and, as a corollary, to understand why stromatolite-building blue-green algae have declined worldwide.

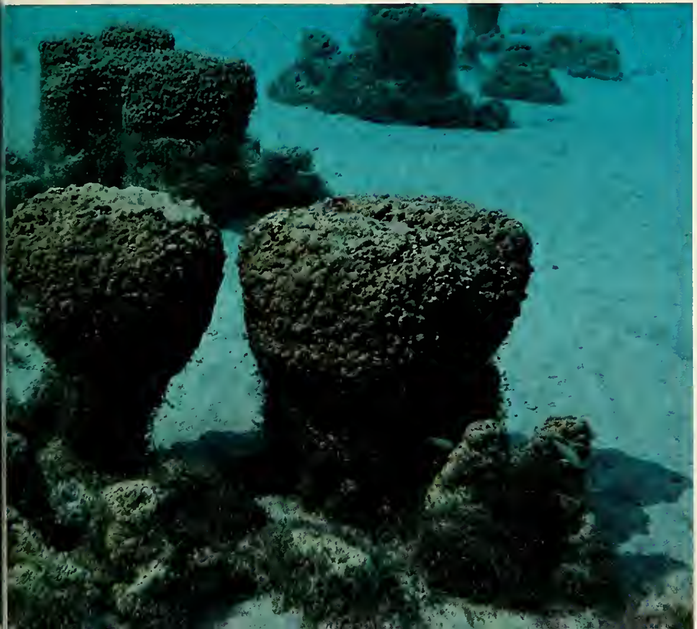
Hamelin Pool is a hypersaline basin, landlocked to the south, west, and east, and partly barred to the north by a shallow sand and sea grass bank known as the Faure Sill. The sill is cut by a number of prominent tidal-exchange channels up to fifteen feet deep, but water depth over most of the sill is less than three feet. Hamelin Pool itself consists of a central basin area up to thirty feet deep, surrounded by a shallow-water shelf and wide intertidal-supratidal flats. High evaporation (annual average about eighty-five inches) and low precipitation (annual average about eight inches) in this area combine with the restricted inflow of oceanic water across the shallow sill to produce salinities up to twice that of normal seawater.

Living stromatolites and the associated sheets of flat algal mats from which they develop cover extensive areas of the intertidal zone and shallow-water shelf, reaching depths of at least ten feet. Older, dead stromatolites, in varying stages of disintegration, commonly occur on the shoreward side of the living intertidal forms and extend to about three feet above sea level. Emergence of these older stromatolites was probably the result of periodic uplift during the past two to three thousand years.

The stromatolites are constructed of sedimentary material, such as shells and lime sand, that has been trapped and bound by matted filaments of blue-green algae. The sediment in, and immediately under, the living algal mats is soft, but a few centimeters below the surface it hardens progressively as a result of the precipitation of calcium-carbonate cement, so that most of the stromatolites are rigid structures.

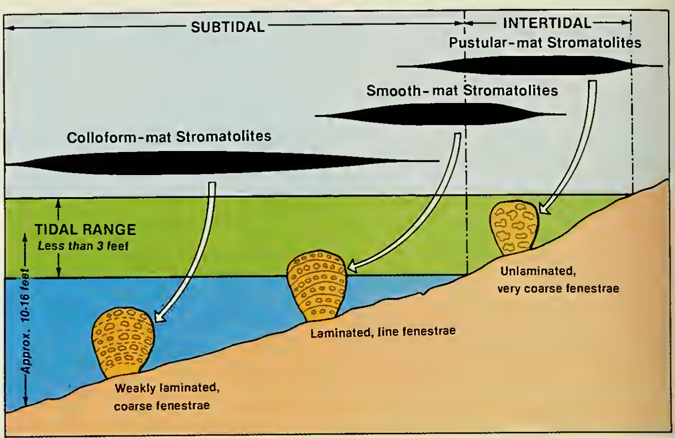
A wide range of shapes and sizes is represented among these stromatolites, from large club-shaped and cylindrical forms to small branching columns. Undulating and columnar shapes are the most common. Three main



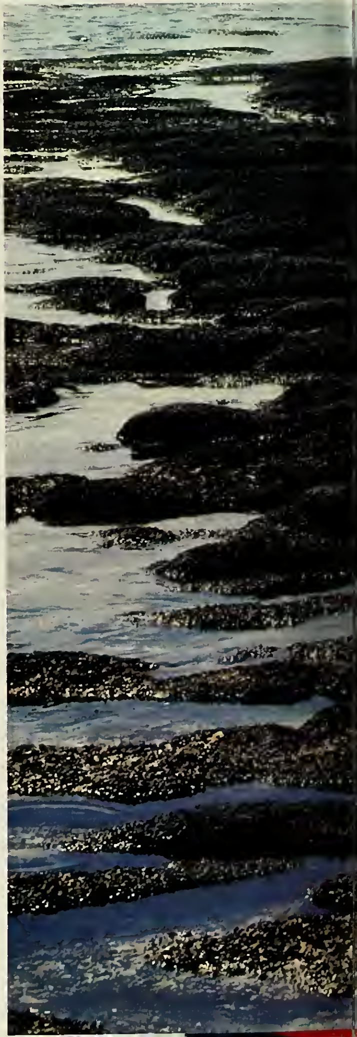


*Above: These living club-shaped stromatolites, photographed at low tide, were constructed by pustular algae, a common type in the intertidal region. Another type of algal mat—colloform—built the club-shaped, conical, and cylindrical stromatolites, left, which are growing in three-foot-deep water at the southern end of Hamelin Pool.*

Stromatolite Distribution at Hamelin Pool



*The strongly developed elongation of these living intertidal stromatolites, at right, is perpendicular to the shore (parallel to the direction of wave translation).*



types of algal mat, each composed of a different assemblage of algal species, construct the stromatolites, and the mat types show a zonation that passes from the upper intertidal region where the algal mat is mainly pustular, through the lower intertidal where it is mainly smooth, to the subtidal where it is mainly colloform.

The stromatolite-building algae occur only on the outer layer of a stromatolite; below the surface they decompose and are therefore not preserved. Nevertheless, some internal characteristics of a stromatolite, such as the presence or lack of lamination and the size and shape of any fenestrae, or internal holes, are governed by the type of algal mat that built it. Its gross, external shape, however, is mainly controlled by environmental factors, including the prevailing wave and wind directions and the nature of the substrate on which it has grown.

Many living stromatolites are elongate and perpendicular to the shore, parallel to the direction of wave translation, and some ancient elongate stromatolites may also have been wave controlled. Other Hamelin Pool stromatolites are elongate parallel to the prevailing southerly winds, which are especially strong and persistent in this area.

Because they generally require a hard foundation on which to grow, the stromatolites are commonly best developed around rocky headlands. Some prominent stromatolite reefs in Hamelin Pool grew on Pleistocene submerged beach ridges, and prominent lines of stromatolites within these reefs are controlled by strongly indurated beds in the underlying beach deposits.

Observations utilizing markers and photographs taken over the past twenty-five years show that the Hamelin Pool stromatolites are extremely slow growing. Most seem to be essentially static, with algal-mat growth approximately balanced by erosion, mainly during storms. The maximum net growth rate of stromatolites that have been marked for the past eight years amounted to less than half a millimeter per year. The slowness of growth suggests that many individual stromatolites must be hundreds of years old.

At one locality, a 1,000-foot-long wagon track cuts through stromatolites on the west side of Hamelin Pool. From about 1915 to 1935 camel-drawn wagons were used to load wool and sandalwood directly onto lighters anchored just beyond the belt of stromatolites. More than forty years have passed since the wagons were last used, but there has been little regrowth of stromatolites over the track, and even single sets of wheel marks that deviate from the main track are still clearly visible. This illustrates the extremely slow growth rates of the stromatolites and their vulnerability to damage by humans.

Fortunately, there has been relatively little human disturbance of the Hamelin Pool environment. The permanent population in the vicinity amounts to fewer than twenty persons on neighboring sheep ranches. The closest town is Denham (population 350), a small fishing and tourist center fifty miles away. The belt of intertidal stromatolites has been declared a nature reserve, and a proposal for extending this reserve over the whole of Hamelin Pool and 130 feet inland is now under consideration.

What is the reason for this unique occurrence of abundant and varied algal stromatolites in Hamelin Pool? The explanation is tied to the unusual hypersaline conditions prevailing there, which have resulted in a major reduction in the diversity of marine life and a paucity of animals that graze on blue-green algae. Of particular relevance is the virtual absence in Hamelin Pool of marine gastropods (snails), which graze on algae; elsewhere in Shark Bay, these animals are abundant. Several fish species occur in Hamelin Pool, some in relatively large numbers, and a single species of bivalve is very abundant, but the total fauna includes only a small fraction of that found in waters of more normal salinity on the other side of the Faure Sill. Although some of the fish in Hamelin Pool graze on blue-green algal mats, the rate at which these few species consume algae is insufficient to prevent stromatolite growth.

An understanding of why algal stromatolites are present in Hamelin Pool helps piece together an explanation for their decline worldwide. Blue-green algae are a remarkable group of organisms that are able to survive a wide range of ecological conditions; many can tolerate periodic desiccation and extreme ranges of temperature and salinity. Their wide ecological tolerance has enabled these organisms to persist, apparently without major evolutionary change, through at least 3.5 billion years of the earth's history. Stromatolite-building blue-green algae, however, have steadily declined in abundance since the early Paleozoic. No doubt a number of factors are responsible for this decline, but the main one is believed to be the proliferation of marine animals that graze on algae. As marine herbivores evolved and extended their habitats, stromatolites were progressively eliminated from most of their former ecological range. They were able to flourish only in environments that remained unfavorable to marine animal life. The best example of such an environment today is Hamelin Pool, where the restricted nature of the marine fauna is analogous to the low diversity of animal life in the world's oceans during the late Precambrian and early Paleozoic eras.

The history of the stromatolites' decline is thus an important ecological example of the progressive suppression of a biological group, forced to the extreme limits of its ecological range by the evolution and adaptive expansion of animals that utilize it as a food source. ☐

James H. Shaw

# Giant Anteaters

*Getting too close to this toothless creature could result in a fatal embrace*

**by James H. Shaw and Tracy S. Carter**

*By feeding for only about thirty seconds at a time and seldom varying their foraging routes, giant anteaters exert minimal predation pressure on a given ant or termite nest. This pattern assures the anteaters a steady supply of food.*

Somewhere in Brazil's interior, a nineteenth-century naturalist named Gardner chased a large, lumbering creature that looked like no other he had ever seen. Easily overtaking his quarry, Gardner seized the animal by its prominent snout and, to his surprise, found himself fighting for his life. The creature, which he thought harmless, rose on its hind legs and with stout forelimbs clasped the naturalist around the middle. Just as its sharp claws began their work on human flesh, Gardner's native companion struck the animal over the head with a club.

Gardner had heard that this strange beast subsisted entirely upon ants and termites, and its diet, together with its shaggy appearance, plantigrade hind feet, and curved claws, led to the animal's popular name "ant bear." Today it is better known as the giant anteater, *Myrmecophaga tridactyla.*

Unrelated to true bears, giant anteaters are members of the order traditionally known as Edentata, a group that includes sloths, anteaters, and armadillos, all of which are restricted to the New World. Although edentata means "without teeth," only the anteaters are completely toothless, while all other edentates have simplified teeth and lack teeth at the front of the mouth. Gardner felt perfectly safe in grabbing the anteater by the snout because he knew it couldn't bite him.

One characteristic shared by all anteaters, armadillos, and sloths is an extra set of articulations of the lumbar vertebrae. Known as xenarthra, these articulations provide additional support for the lower vertebral column, permitting many of these species to assume sturdy bipedal stances. Many zoologists believe that this order of mammals merits the more accurate and consistent name of Xenarthra.

Some of the earliest-known fossil xenarthrans were North American, but it was in the Tertiary (sixty-five million to two million years ago) environments of South America that the group achieved its main evolutionary success. One branch gave rise to the armadillos, of which there are about twenty living species, including the familiar nine-banded armadillo, the only xenarthran occurring in the United States. A second branch developed into five contemporary sloth species and four species of modern anteaters.

Geographically isolated throughout the Tertiary, South America reunited with North America about two million years ago, and a faunal exchange began. Some of the invaders from North America proved to be such formidable competitors that many South American species were driven to extinction. But the xenarthrans persisted, and some, such as the giant ground sloth, became well established in North America.

Xenarthrans are still a major mammalian group among South America's native fauna. In some places they are ecologically dominant, achieving greater biomass (the weight of living material) per unit area than any other group of mammals. Researchers at Barro Colorado Island, a tropical forest habitat in Panama, found that the biomass of sloths and anteaters exceeded that of any other native mammals. Thousands of miles to the southeast in the high-altitude Brazilian grassland of Serra da Canastra, a new 200,000-acre national park in Brazil's eastern highlands, we learned that anteaters and armadillos were the dominant animals. At the invitation of Brazil's federal conservation agency, we did field studies on the giant anteaters in the park and were fortunate enough to see eighteen giant anteaters there in a single day. Canastra's terrain made it possible to spot anteaters at distances of more than a mile. We made a series of counts and estimated the anteater population at between three and five per square mile, not bad for a large predator.

Giant anteaters average about six feet in length, stand two feet high, and weigh an average of seventy pounds. Their skull is longer than a grizzly bear's, yet scarcely wider than a jackrabbit's. Characteristic markings include long, coarse hair along the back and tail, distinctive, horizontal black bands on the forefeet, and a dark lateral stripe. This stripe tapers like a banner, leading to the popular Brazilian name *tamanduá bandeira*, or literally, "flagged anteater." Markings differ considerably between giant anteaters, often making it possible to distinguish between individuals. We named one anteater in our study area Wing because its lateral stripe resembled the outstretched wing of a bird.

Giant anteaters are tiny at birth. We weighed two newborns that tipped the scales at less than three pounds. By the end of their first year, anteaters weigh between twenty-eight and thirty-three pounds, apparently reaching full weight (seventy pounds) by the end of their second year.

Although the species still ranges from Central America to southern Brazil, it is officially recognized as endangered. The principal reason for its decline is deliberate killing by people, who regard the giant anteater as, at best, worthless or, at worst, dangerous. The meat is sometimes consumed, but the giant anteater has little commercial value. A low reproductive rate, no more than one young per year, makes it difficult for anteater populations to tolerate this relatively new form of mortality. The high population density in Canastra appears to be a rare exception brought on by the area's remoteness and, more recently, by protection within the national park. Some authorities believe that a similar pattern of killing brought about the extinction of the anteater's largest relative, the giant ground sloth. Evidence from both North and South America shows that prehistoric humans killed giant sloths, and some paleontologists have concluded that this overkill brought about the species' extinction.

Its low reproductive rate, poorly developed senses, and generally unwary nature make the giant anteater vulnerable. Because of its poor vision and none-too-keen hearing, the animal is forced to rely mainly upon its sense of smell. With the wind in our favor, we have frequently made observations from within ten feet of foraging anteaters in open grassland. This lack of wariness makes the anteater an easy mark for any sort of firearm or even a hefty rock. Riflemen often kill them, apparently for target practice. While conducting a field study in Canastra, mammalogist Bryan Glass discovered a giant anteater skull with a bullet hole punched neatly through the brain case. The animals make tempting targets, even in relatively protected areas.

Throughout South America the giant anteater is believed dangerous to

*Riding on its mother's back, a baby giant anteater aligns its lateral stripe with hers, so that the two animals appear to be one. The mother carries the cub in this fashion for several months, affording it a measure of protection from predators.*

Tom Stack; Tom Stack and Associates

humans. Brazilians even have a term for Gardner's traumatic experience, the *abraço da tamanduá*, or "embrace of the anteater," a sometimes fatal experience for those who get too close. One bizarre claim is that a giant anteater can suffocate a person by placing its snout over the victim's mouth and nose. Since the snout's diameter is only an inch or so at the tip, such a feat would require considerable cooperation by the victim.

Years ago, a wounded giant anteater was said to have killed a small boy in Ecuador. The youngster was accompanying some men on a hunt. When his father wounded a giant anteater, the boy tried to dispatch it with his machete. The anteater embraced and fatally clawed him.

How dangerous is the giant anteater? Surely Gardner's story and the Ecuadorean incident demonstrate that the animal is capable of injuring and even killing people. But to gain perspective on this question, we need to consider the species' life history, particularly how it deals with danger in its natural environment. For the past two million years, the giant anteater has shared its domain with big cats, notably the jaguar and the puma. Marsupial predators, including a saber-toothed version the size of a modern leopard, posed a danger to anteaters prior to the big cats' arrival. Since the anteater is unwary, slow running, and can barely climb trees, how has it coped with predators? The answer seems to lie in a rapid and effective defensive reaction in which the animal uses its sharp claws and strong forelegs. Dogs foolish enough to attack giant anteaters are usually disemboweled. South American Indians commonly state that giant anteaters even kill jaguars. While this last claim is difficult to document, the defensive reactions of giant anteaters have probably taught big predators to rely on

*An anteater plucks termites from a mound with its twenty-inch-long tongue. Contrary to popular belief, the anteaters' tongues are not sticky and they do not capture their insect prey by using that appendage as flypaper. The bites of ants can drive an anteater away.*

Francisco Grize, Bruce Coleman

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safer prey. The large claws on the giant anteater's forefeet may serve more for defense than for tearing into termite and ant nests, their presumed primary function. We have yet to see a giant anteater breaking into an insect nest and believe that most of their feeding is relatively passive.

The giant anteater responds to sudden attack from a human in essentially the same way it meets an attack from any other predator. Its actions are purely defensive and, as far as we know, can only be elicited by direct contact. In all our hours of closeup observations, we never felt the slightest bit threatened. Whenever an anteater detected us, it would invariably move away as fast as its clumsy gait could carry it, but the animal is poorly designed for hasty retreat. Its slow running motion has been compared to that of a rocking horse. When running or walking, the animal protects its claws by tucking them under, turning them inward, and striding on the outer edges of its forefeet. This awkward arrangement results in a clumsy running gait, accentuated by the long, coarse hair flopping along its back. After running a few dozen yards, frightened anteaters often stop and begin feeding on the nearest ant nest, apparently forgetting that possible danger still lurks nearby.

The giant anteater's defense against predators poses a problem. A species endowed with formidable weapons needs a way to resolve conflict among individual members without inflicting serious injury. One way is ritualization, in which intent is expressed while physical combat is restrained. We once witnessed such a ritual when one giant anteater wandered into an area in which a second anteater was foraging. After catching the scent of the wanderer, the forager immediately ran toward it and the ritual began. The two circled one another with tails raised high and pushed at each other's shoulders with their forepaws. Serious injury was avoided since the deadly claws were kept carefully tucked. After a few minutes of circling and pushing, the combatants seemed to settle their dispute and each moved slowly away in the direction from which it had come.

*The size and shape of lateral stripes vary greatly among giant anteaters, making it possible for researchers to recognize the individual animals they are studying in the field. The heavy coat of hair probably helps the anteater save body heat.*

m McHugh, Photo Researchers

Another question that has long puzzled naturalists is, How can an animal the size of a giant anteater sustain itself on a diet of ants and termites? Only recently have key pieces of the puzzle begun to fit together. Part of the answer lies in the foraging pattern. Giant anteaters feed only half a minute or less on each ant nest, after which the biting and stinging of the insects apparently drive them away. Furthermore, anteaters tend to move in a constant direction between insect nests, seldom altering their foraging routes by more than a few degrees. This way they reduce the chances of raiding the same nest within their feeding ranges twice. The limited feeding time and movement pattern represent an efficient means of cropping prey and assure the anteaters a steady food supply.

There are a couple of persistent myths about the way in which anteaters feed. The first is that the beast captures insects with its "sticky" tongue. Although moist and equipped with tiny villi, the twenty-inch-long tongue is not sticky. Another related myth is that the giant anteater uses its tongue flypaper fashion to entrap entire columns of ants. After spending dozens of hours watching anteaters feed on thousands of insect nests, we have yet to see one lying comfortably beside a trail, tongue extended, collecting marching ants. A good idea, perhaps, but the anteaters haven't learned the trick.

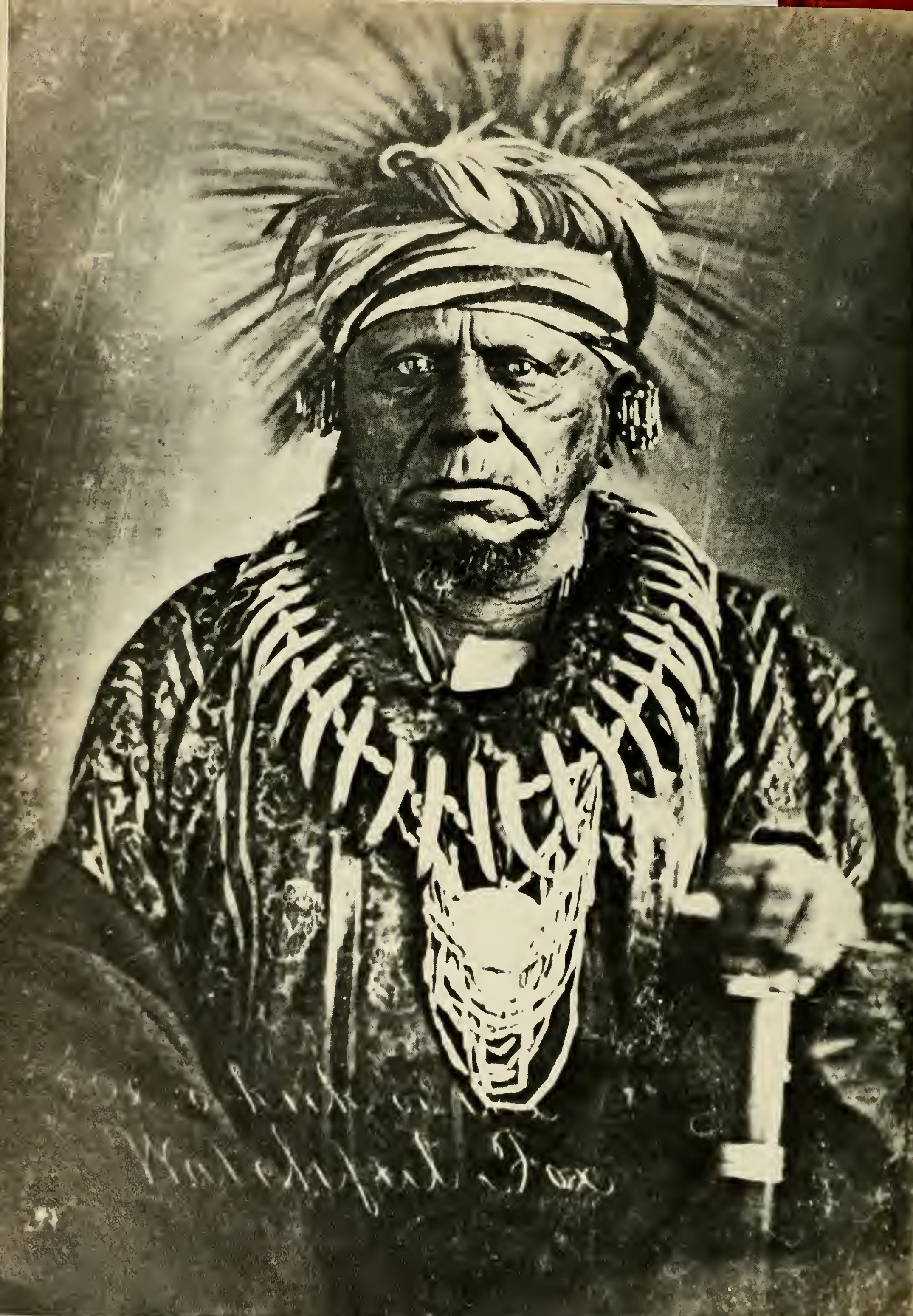
Another part of the energetic puzzle was recently solved by Brian McNab of the University of Florida. McNab measured metabolism in the giant anteater and discovered that its basal metabolism was only about one-third that expected for a mammal of its size. Low metabolic rate means low energy demand and may represent a further adaptation to an unusually specialized diet. This low metabolism may also explain why the giant anteater, a tropical species, has developed such a heavy, dense, coat of hair. A mammal with so low a rate of metabolism may actually need that hair to retain body heat, even in the tropics. When sleeping, the anteater folds its bushy tail over its body to conserve body heat. This sleeping position also serves to camouflage the sleeping animal by breaking up any telltale outline.

Camouflage is also used by anteater cubs. A female anteater carries her single cub on her back for several months. The cub is hard to see because it clings where its mother's hair is densest. It seems to align its own exposed lateral stripe with its mother's, making the two appear to be one animal.

Other than females with young, giant anteaters are generally solitary creatures. When two adults are seen together there is no way of knowing whether or not they are a mated pair. The sexes can only be distinguished by close inspection. This similarity between sexes gave rise to a local belief near Canastra that all giant anteaters are females and procreate by mating with lesser anteaters (*Tamandua tetradactyla*).

Recently we used radio telemetry to study movements of giant anteaters but only after we overcame problems posed by the species' peculiar anatomy. Neck collars, the usual means of attaching transmitters to wild mammals, were inappropriate in this case. So we fashioned various kinds of shoulder harnesses with which to secure transmitters and found that they generally worked well. When a couple of the more determined animals learned to wriggle out of their harnesses, we recaptured them and, taking advantage of their long, coarse hair, actually braided transmitters onto them. The radio tracking showed quite clearly that home ranges overlapped in both sexes, indicating that the species is not territorial. However, territoriality among mammals is not so simple a proposition as it was once thought to be. Perhaps under different combinations of population densities and food supplies, giant anteaters might behave differently and maintain exclusive home ranges.

The outlook for the giant anteater is still good. While obviously vulnerable, it is widely distributed in different habitat types on a continent blessed with abundant ants and termites. The Brazilian government has granted the species protection, and new national parks such as Canastra will assure preservation of natural habitat. Perhaps people will become more tolerant of the anteater as they learn that it poses no real danger if unmolested. ☐



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# Posing the American Indian

*Early photographers often clothed reality in their own stereotypes*

**by Margaret B. Blackman**

Several summers ago I returned to the Haida Indian reserve in northern British Columbia, where I had conducted anthropological research, and I recall being both startled and amused when a native bearing a Nikon camera turned to snap my photograph. (Coincidentally, I was giving a lecture on historic photographs of Haida villages taken during the last one hundred years.) Like many native subjects who have faced the cameras of anthropologists, I never saw the final product. Perhaps, fittingly, it is now part of a photo collection depicting anthropologists who have studied this Indian community. Today, cameras, photographs, and photo albums are as much a part of Native American culture as they are of the larger American community.

In the past, however, it was the white man who communicated the popular image of the Indian through paintings, drawings, and most important—in terms of their historical value—still photographs. In every picture we find two kinds of enlightening statements, one about the artist or author and his conception of the subject material and a second about the culture captured in the picture. These statements might be labeled "stereotype" and "reality," respectively. In recent years, the public has become more sensitive to the existence of stereotypes; the documentary value of the visual record, however, is just beginning to be realized.

*The earliest documented photograph of an American Indian is this 1847 daguerrotype, by Thomas M. Easterly, of Keokuk, leader of the combined Sauk and Fox tribes.*

ithsonian Institution National Anthropological Archives

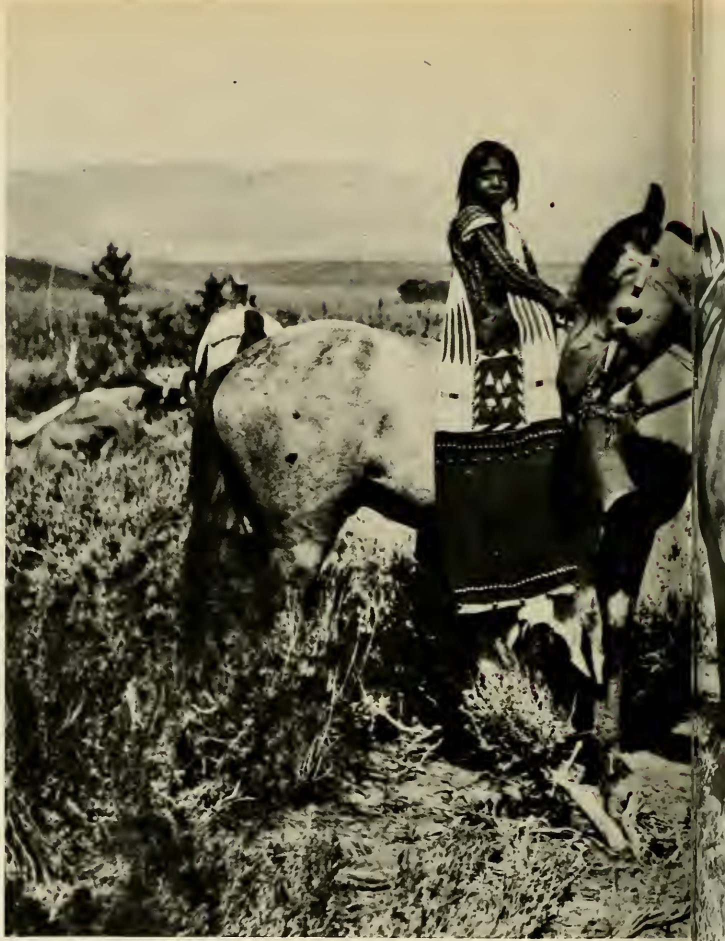
There is a wealth of photographs of American Indian life and culture. The American Museum of Natural History houses a comprehensive collection, and regional museums such as the British Columbia Provincial Museum have substantial holdings respecting local native cultures. Probably the largest collection belongs to the Smithsonian Institution, whose National Anthropological Archives has cataloged more than 30,000 black-and-white prints of American Indians.

Photography began with the invention of the daguerrotype in 1839, but slow exposure times (eight to thirty minutes) made recording anything that lived and breathed more than a little difficult. Nevertheless, with headrests and patience on the part of the subject, portraiture with the daguerrotype was possible. The earliest documented photograph of an American Indian is an 1847 daguerrotype of Keokuk, leader of the combined Sauk and Fox tribes after the War of 1812. Several years earlier both George Catlin and Charles Bird King had recorded Keokuk's likeness on canvas. King, a portrait painter, became famous for his renderings of Indian visitors to the nation's capital. By the late 1850s, however, the camera had supplanted portraiture, and Indian delegations had their images recorded in photography studios.

Occasionally, a photographer accompanied a treaty party from Washington, D.C., to the West, but documentary field photography did not become established until after Mathew Brady used his camera to register the travails of the Civil War. By the 1870s photographs of Native Americans in their home settings were no longer the exception, although photography was still a cumbersome process. William Henry Jackson, official photographer on the 1870 Hayden Expedition, carried with him a staggering array of equipment and supplies, including three cameras, two tripods, a dark tent, many pounds of chemicals, and four hundred glass negatives. Jackson and other photographers of his time relied upon the wet-plate process, a procedure that required coating the glass-plate negative with a light-sensitive emulsion, then exposing and developing the negative while the emulsion was still wet. It took Jackson half an hour to make and process a negative. Exposure times with the wet plates were still fairly slow—ten to fifteen seconds—and American Indian life recorded by the wet-plate process was a still life.

In 1871 the British *Journal of Photography* reported the invention of gelatin-coated glass-plate negatives that did not require exposure and developing while still wet. But these early "dry plates" were even less light sensitive and thus slower than contemporary wet-plate negatives. By 1880, however, when the dry plate was officially sanctioned by the Photographers' Association of America, exposure times had been reduced to one-

*"A warrior and his bride" were among the Ute Indians posed by John K. Hillers, photographer on Major Powell's 1873 Colorado River Expedition. Such pictures were often made for public consumption.*



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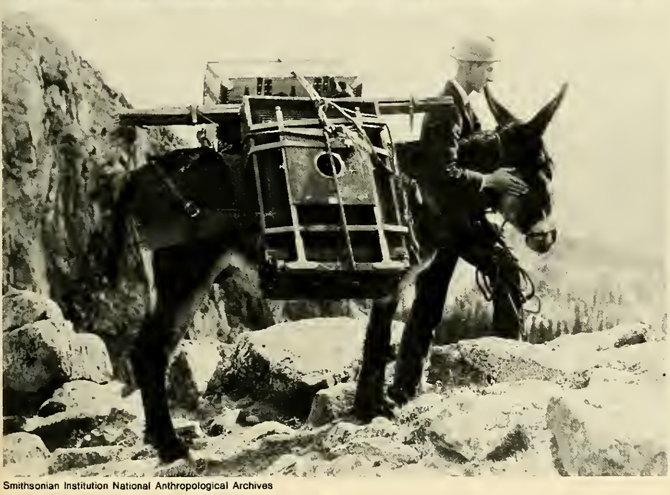
sixth to one-twelfth that of the wet plates. Two years later the dry plate was firmly entrenched in American photography. Nevertheless, some time probably went by before Indians in well-traveled areas of the country became familiar with the faster process. In 1885, for example, a Tlingit Indian boarded an Alaska Steamship Company steamer docked at Sitka and, seeing a photographer taking pictures on deck, requested to be photographed. An observer reported, "The Indian stiffened himself into his most rigid attitude and when the process was over could hardly be made to stir from his pose."

While photographers often accompanied early ethnographic expeditions to Indian settlements, their motives were usually not strictly ethnographic. John K. Hillers, who served as photographer for John Wesley Powell's 1873 Colorado River Expedition, provides a good example. A number of Hillers's photographs of Ute and Paiute Indians were used by Powell to illustrate some of his publications on Great Basin Indians. Many, however, were taken with a stereo camera and mounted on cards for viewing through parlor stereoscopes, evidence that entertainment value governed the selection of subject matter. The barebreasted "Wu-nav-ai gathering seeds" certainly was not viewed by Victorian gentlemen for its documentation of Great Basin seed gathering. Hillers's stereo images, marketed with a U.S. Department of the Interior label on the backs of the cards, proved most lucrative, netting $4,100 in the first six months of their sale in 1874.

Even Franz Boas, the father of American anthropology and meticulous chronicler of Northwest Coast Indian cultures, saw photography of Native Americans in commercial, as much as ethnographic terms. In the winter of 1895/96 Boas hired C.O. Hastings, a photographer from Victoria, to accompany him to Fort Rupert and assist in recording Kwakiutl Indian technology and portions of the elaborate winter ceremonies then in progress. Together, Boas and Hastings returned with 140 photographs, which the anthropologist hoped to be able to sell to *Scribners* or some other magazine. The *Scribners* photo essay never came to fruition, but many of the photographs illustrated Boas's *The Social Organization and Secret Societies of the Kwakiutl Indians,* published in 1897 as a U.S. National Museum Report, and these, and others, are in the photo archives of the Smithsonian Institution and the American Museum of Natural History.

With expedition photographers and even, I suspect, with Boas, there was a strong motivation to photograph what would sell to the public; and the more exotic, the more salable. As far as many early photographers were concerned, the costume made the Indian. Researcher Joanna Scherer (to whom goes credit for previously presenting and analyzing many of the photographs republished here) has described how the Plains Indian stereotype was imposed upon the non-Plains Ute and Southern Paiute when Hillers photographed many wearing buckskins and feather headdresses, costumes that had been ordered by Major Powell. Frontier studio photographers routinely kept a stock of Indian costumes with which to attire local native subjects. The result was that several natives were often photographed in the same outfit or one native might be photographed in two or more different outfits.

Edward Sheriff Curtis, the most famous photographer of Indian subject



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material, costumed his subjects with much greater attention to ethnographic accuracy. Over a period of nearly thirty years, Curtis visited more than eighty different Indian groups, collecting ethnographic material for his *The North American Indian,* published in twenty volumes between 1907 and 1930. His volumes were illustrated with some 700 photographs culled from the more than 40,000 he took in his travels. Curtis had a romanticized view of the American Indian, but one that was tempered with the ethnographer's concern for accuracy. Writing of his photographic work, Curtis said, "These pictures were to be transcriptions for future generations that they might behold the Indian as nearly lifelike as possible as he moved about before he ever saw a paleface or knew there was anything human or in nature other than what he himself had seen."

To effect a precontact image of some of his subjects, Curtis carried with him a wardrobe of museum props. In 1971 while doing research on historic photographs of Haida culture for my doctoral dissertation, I discovered that Curtis's props did not stop with garments and ceremonial paraphernalia. I was baffled that older Haida recognized all the Haida women Curtis had photographed but could identify none of the men in his photographs. Finally, an older man recognized the face of Alfred Adams in one portrait, but noted that, in contrast to the Curtis image of him, Adams had always worn his hair short in the style of the early twentieth century. Later I learned that all the Northwest Coast males in Curtis's photographs were bewigged. The short haircuts of the native men would never have served to present the view of the native that Curtis tried to reconstruct before his camera.

Curtis's hauntingly beautiful photographs do evoke a mood, and his much admired images sparked imitation of the genre. One such imitator was B.W. Leeson, a British Columbia

*Field photography once involved the transport of glass negatives and other heavy equipment. On the 1870 Hayden Expedition, William Henry Jackson photographed his "assistants."*

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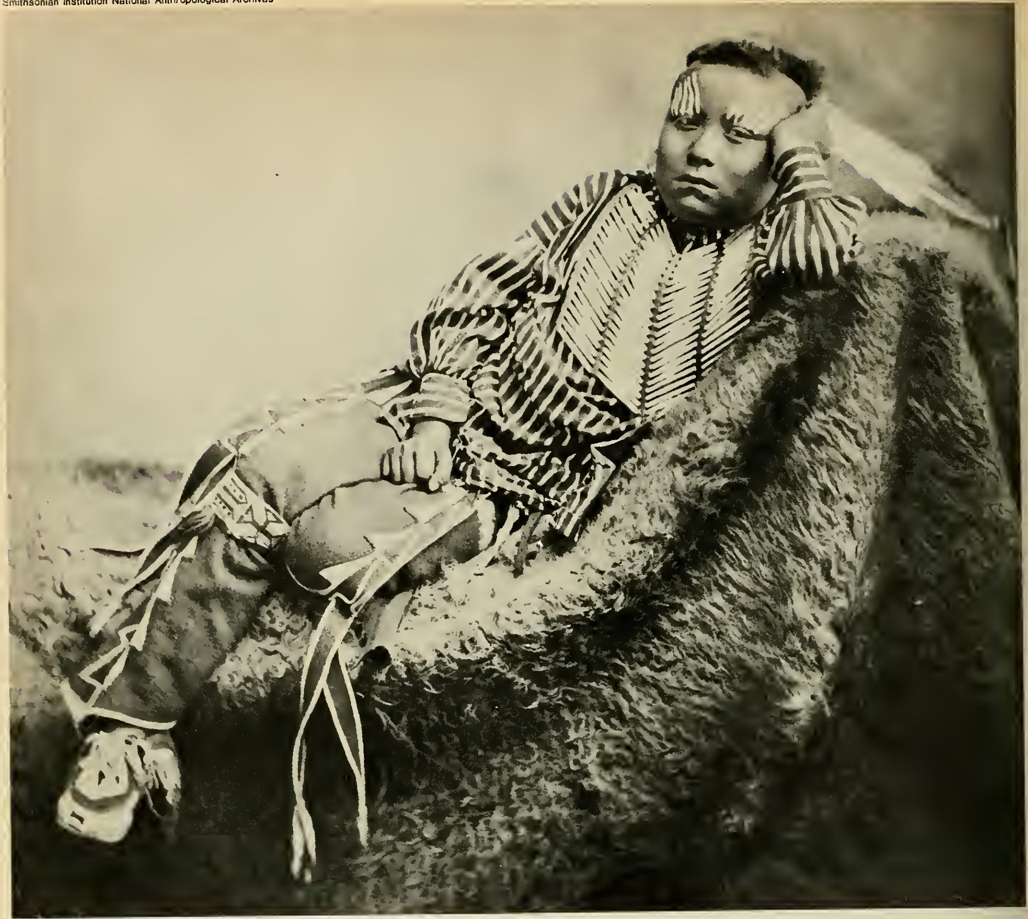


*Lone Bear's face paint was apparently added after his picture was taken by William Soule. The boy wears an Osage costume, but since he also posed as a Kiowa, his tribal identity is uncertain.*

photographer, who wrote of his successes in photographing Indians for *Cameracraft* magazine in 1914. Leeson, like Curtis, knew artistic license was quite possible with the camera, that the photographer could depict the subject as he wished. In Leeson's case, however, the result was often a contrived sentimentality. Leeson was especially fond of "The Passing of the Indian," a photograph he made and marketed; he revealed the secret of its success to *Cameracraft* readers:

> I have always appreciated the difference between a record photograph and a photographic picture and have made many attempts at the latter; the picture, "The Passing of the Indian" being one of my latest and most successful efforts. The figure is that of the last remaining member of the Klaskeno tribe who lives with his wife here at Quatsino. I explained to him just what I wished to do, show him as the last of his tribe, asking him to look "sick tum tum" and he responded quite well.

The power of the pictorial was recognized by Indians themselves, who were not only subjects for photographs but often customers as well. Leeson catered to their tastes.

> It is the liking of the younger Indians, particularly the girls, to fix up and be photographed. Asked to pose [for traditional shots] they will rub on white paint, blacken their eyebrows and squeeze themselves into tight corsets, looking about as impossible, from a pictorial point of view as they can. I pose them inside some ranch enclosure with a strong front light, and then, with a little manipulation of the negatives, I make them look like beautiful blondes. They will each want one print.

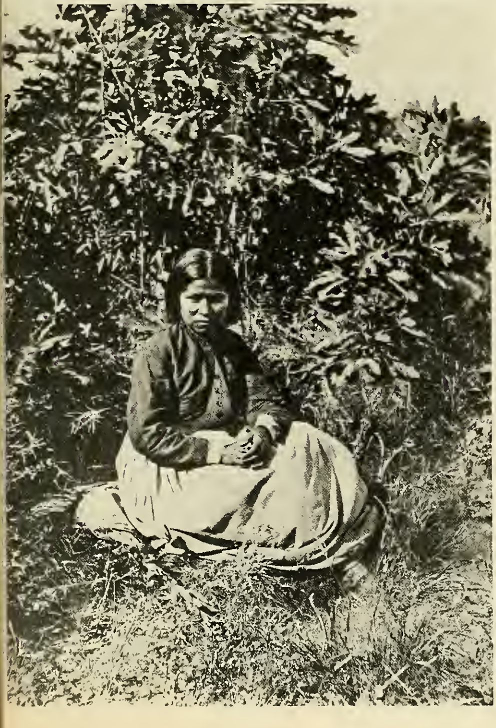
Not all Native Americans were lured into seeking the photographer's services in order to look like whites; by the turn of the century, many recognized the cultural and personal historical value of the visual record. What else could explain the hiring of a photographer to record a family funeral, a wedding, a family gathered on the front porch of its home, the village band, and other mundane, nonexotic scenes? Such photographs were not studio-marketed curiosities; they were commissioned by Indians for Indian use. One elderly Haida woman I know, the legatee of nearly one hundred early-twentieth-century images, realizing their larger historical value, lent them to the Smithsonian for copying. They speak to the realities of native life as it actually was when Curtis was busy trying to recapture it as it had been some two hundred years before.

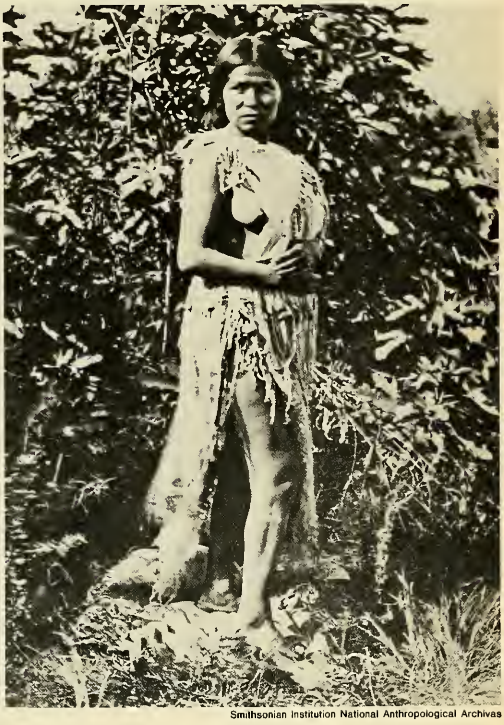
For the anthropologist and historian of American Indian cultures, photographs of Native Americans are important if for no other reason than photography evolved at a time when these cultures were undergoing rapid, intensive change. Unwittingly perhaps, photographers documented many changes that few anthropologists of the time were interested in, concerned as they were with reconstructing the past. Two examples from the Northwest Coast hint at the uses to which photographic documents can be put and the kinds of problems they shed light on.

The Haida village of Kasaan in southeastern Alaska was frequented during the 1880s and 1890s by U.S. revenue cutters, fisheries boats, and steamships of the Alaska Steamship Company on their cannery-tending junkets. Navy personnel, fisheries officers, and other government officials, as well as tourists aboard these ships had a hand in making Kasaan the most photographed Haida village. Although no one, except perhaps the earliest photographer of the village (Albert Niblack, in 1885), set out to systematically record the entire village, there are more than seventy photographs, taken between 1885 and 1902, when the village was abandoned, recording every house, every totem pole, and virtually every deletion and addition to the façade of the settlement. We know largely, if not exclusively, from the photographs how Kasaan's people were affected by the introduction of Christian mortuary customs, how they adapted white styles of architecture to their native dwellings, what innovations they made in the carving of totem poles, when they quit raising totem poles, and a number of other particular cultural changes. And for those interested in how abandoned villages in the Northwest Coast rain forest deteriorate, and the rapidity with which such deterioration takes place, there are numerous photographs of Kasaan taken at intervals after its abandonment.

Some sixty miles to the south of Kasaan, in the village of Masset in the Queen Charlotte Islands, stood what was reputed to be the largest Haida house ever constructed, that of Chief Wiha. Perhaps because of the personage of its owner, its size, and its central location in the village, *Neiwans*—"the Monster House"—was one of the most photographed Haida dwellings. It was first featured prominently in George M. Dawson's 1878 photographs of Masset, and appeared in various photographs over the years. In 1897 E.P. Allen of the Field Museum in Chicago recorded an abandoned and weathered *Neiwans*, its side planks and windows missing. In 1919, Harlan Smith of the National Museums of Canada photographed *Neiwans*'s successor, a modest cottage less

*J.K. Hillers pictured Kaiar, a Paiute woman, modeling a garment, below, that if anything, is too elaborate for traditional summer wear. The calico dress, at left, is more likely her own.*





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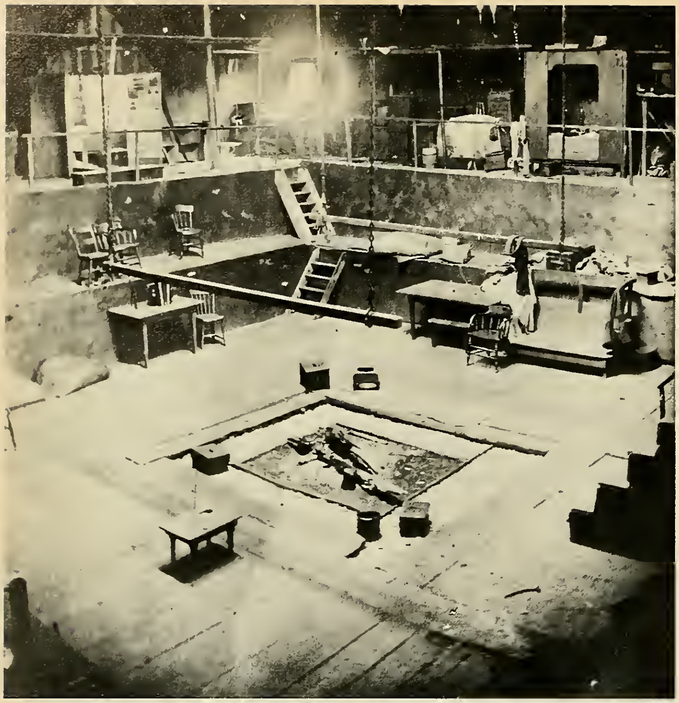

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*Nonnative items arranged in a native space are evident in Richard Maynard's 1884 view of* Neiwans, *the house of a Haida Indian chief. Such photographs document an era of intense cultural change.*

than a third the dimensions of the former great house. An anthropologist who worked at Masset in the mid-1960s gave me a color slide of a two-story house that replaced the cottage in the 1930s, and more recently I photographed the modern one-story dwelling that stands on the site today.

The most revealing and intriguing view of Wiha's house comes from the American Museum's photograph collection. Taken originally as a stereo view by Richard Maynard in the spring of 1884, it depicts about two-thirds of the interior of *Neiwans* and is one of only a handful of photographs of Northwest Coast native house interiors from the last century. As a visual document, the Maynard photo says much about this Haida household's exposure to, and acceptance of, the wave of changes that had confronted it by the 1880s. The careful investigator can pick out a coffee pot, an accordion, a child's potty stool, newspaper photographs, and as many as thirty other items of nonnative origin shown in the photo, but he or she might have a hard time identifying anything distinctively native about the house's contents. The native artifacts consist primarily of cedar bark sleeping mats and storage boxes.

Yet all the material items are arranged within a native space; the organization of this household and the distribution of its nowhere-to-be-seen personnel was Haida, not Canadian. One can detect the importance of the upper level as reflected in the bedchambers; the attention given the rear portion of the house, with the chief's chamber and the several chairs and tables where Wiha or his successor may have entertained visiting dignitaries; the housepit as an area for social interaction, food preparation, and eating. We know, too, from other photographs of Masset that members of Wiha's house continued to occupy a native style of dwelling while others around them opted to build white-style houses.

The photographs of Wiha's house also prove instructive with respect to Haida architecture. It is possible to learn from the photographs and from archeological data at the house site some of the actual dimensions of the structure and several of its associated totem poles, features that disappeared about 1904 when the house and poles were razed. A lower housepit retaining wall, measuring forty-six inches in height, is preserved intact beneath the present house that sits on the site. Using this single dimension, it is possible through photogrammetry (a science for determining true distances from measurements made on photographs) to obtain measurements for all the house parts shown in the photographs. Applying the method on a larger scale, plans and elevation drawings of the entire village could be reconstructed to scale and might help an anthropologist inspect settlement patterns in great detail or might form the basis for actual reconstruction of portions of the village at some future date. Large-scale photogrammetric reconstruction of village sites has already been applied in at least one southwestern Pueblo Indian settlement.

The visual record of Native American cultures from the last one hundred years or so has much to offer to people of diverse interests. For the cultural anthropologist, such as myself, it reveals something of day-to-day life during a period of time that was not of much interest to an earlier generation of anthropologists, who looked to more remote periods of cultural history. For the archeologist, photographs of villages and housing complement and augment the artifacts excavated at village sites. And for the native descendants of those photographed, the images are a personal history of a bygone era. The visual record has much to communicate about stereotypes of American Indians, the way they really lived, and the contact and, sometimes, conflict between opposing ways of life. ☐

*To Sky Striking the Earth, who sat for William Dinwiddie at the Smithsonian in 1897, a feather duster may have seemed the best available substitute for a traditional Chippewa headdress.*

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# A New Supernova

*An unfamiliar exploding star provides insights into these objects*

**by Stephen P. Maran**

Stellar explosions, or supernovae, are relatively rare in any one galaxy. Studies of spiral galaxies indicate that they occur typically at rates of one to ten per century in large galactic systems such as our own. The last authenticated supernova seen in the Milky Way was Kepler's star of A.D. 1604. (Another may have occurred later in the seventeenth century but was somehow missed by all or almost all observers.)

Supernovae discovered by amateur astronomers are especially rare. But last year, an amateur astronomer alerted professionals to a supernova in a faraway galaxy. Monitoring the event with satellite and ground-based telescopes, the professionals gleaned new facts about the progress of the explosion, the previous state of the disrupted star, and the distant galaxy itself.

The amateur was Gus E. Johnson of Swanton, Maryland, a member of the American Association of Variable Star Observers. That group, AAVSO for short, encourages its lay members to study pulsating stars and to search for exploding ones. It was to AAVSO headquarters in Cambridge, Massachusetts, that Johnson made his report. The report came in on April 19, 1979, the night after he had made a visual "tour" of northern galaxies, inspecting one after the other with an eight-inch telescope.

Midway through his April 18 tour, Johnson turned the small telescope toward M100, a striking spiral galaxy seen nearly face-on from the earth, in the constellation Coma Berenices. An unfamiliar star of the eleventh magnitude, fairly bright by telescopic standards, stood out against the galaxy. Either it was a foreground star, relatively near the earth, which Johnson had not noticed before, or it was in the distant galaxy and hence must be immensely bright. In the latter case, the object would have to be a supernova, for such exploding stars outshine all other stars until their erupting matter has thinned out as it continues rushing into space.

A check with the *Hubble Atlas of Galaxies* showed that the object was not a foreground star, and spectograms taken with professional telescopes soon confirmed that it was a supernova of Type II, meaning the explosion of a massive supergiant star. Subsequent calculation indicates that Johnson's star, the fourth supernova found in M100 since 1901, was about 6.3 billion times brighter than the sun, although visible only with a telescope.

The estimate of the brightness is at best approximate because astronomers' measurements of the distance of the M100 galaxy are in conflict, ranging from 37 million to 78 million light-years. (One light-year, the distance traveled by light moving at 186,000 miles per second during the course of a year, is about 5.8 trillion miles.) In any case, the brightness of the Johnson supernova surely exceeded three billion suns, with the larger above estimate the best guess at present.

Since supernovae have been lacking in the Milky Way recently, astronomers have perforce focused on other galaxies to study them. By scanning many galaxies, one can find several supernovae per year, even though the explosions are rare within any one galaxy. Two computerized telescopes have been developed to search the galaxies, but they have not been very successful and most supernovae are still discovered on patrol photographs made with simpler telescopes. The problem with patrol photography, however, is that unless the film is developed and carefully examined immediately (which doesn't always happen), a supernova will have faded substantially by the time it is noticed on the photographs and astronomers will miss the chance to observe the rapidly changing early stages of the explosion.

By contrast, a visual search such as Johnson's has the advantage of letting the viewer know at once that a supernova may have been found. The disadvantage is contained in the word "may": most visual supernova sightings turn out to be false alarms. Further, using only the eye and telescope, even careful searches are limited to relatively bright and nearby objects and hence miss the many fainter, more distant supernovae that are found by time-exposure telescopic photography. According to the AAVSO, Johnson may be only the second person to visually discover a supernova in the twentieth century.

Immediately after the discovery was announced, astronomers began studying the new star, which was brighter than usual for an extragalactic supernova. The most extensive efforts were made by a team of twenty-three European researchers led by Nino Panagia, a supernova expert at the Radio Astronomy Institute in Bologna, Italy.

Using ground-based telescopes, the team measured the velocity of the hot gas erupting from the supernova. It was found to be about 6,200 miles per second at first and slower later on. As the gas expanded, the supernova began to fade. Each night the star became about 4½ percent less bright. Radio telescopes in West Germany and New Mexico, also searching for the supernova, have found no signals from it yet but may detect it eventually when the expanding gas cloud is sufficiently thin and large. Two satellites looking for X-rays have also had no reported success so far.

The most interesting findings have come from a series of observations that Panagia made with an ultraviolet observatory satellite, the IUE (see "Telescope in Space," *Natural History*, July 1980). With the satellite equipment, he photographed the changing ultraviolet spectrum of the supernova and found three principal features, each corresponding to a different property of either the star or of its parent galaxy, M100.

The first feature was the continuum, that is, the general glow of ultraviolet light at all wavelengths. Analysis shows that this radiation comes from the outermost layer of the expanding gas that is still opaque. (Above the layer, light travels freely through the thinner gas; in the denser region below, light is strongly absorbed.) A layer of this sort, which resembles a surface when seen by an external observer, is called a photosphere, or sphere of light. That opaque layer is the same region that produces the visible light of the supernova seen from the ground.

Over a period of six weeks in April and May, the Europeans found that the photosphere cooled from about 11,000°C to about 7,000°C as it expanded. As the gas thinned, light escaped from deeper layers, where material ejected from the explosion at lower speeds was located. (The fastest stuff, of course, must be farthest out.) This circumstance probably accounts for the gradual slowing of the expansion, which as mentioned above, was found with ground-based telescopes. Gravity had a slight retarding effect, but the observed "slowing" may be mostly an illusion caused by the gradual uncovering of slower-moving gas that was present all along, while the faster-moving gas thinned and faded away first.

The second feature found by the IUE satellite was the absorption lines, that is, dark, narrow bands where the continuum light is reduced due to absorption by atoms along the line of sight to the supernova. In the July 1980 Sky Reporter column in *Natural History*, I told how such lines have revealed the presence of a "galactic corona" of thin, hot gas around the Milky Way. Thanks to its great brightness, the M100 supernova functioned effectively as a background lamp against which Panagia detected the absorptions of the Milky Way's corona and also a second set of similar absorption lines produced in M100 itself. (The two sets were readily distinguished as all the lines in the second set had red shifts corresponding to the 1,000 miles per second motion of the M100 galaxy away from the earth. This motion is caused by the expansion of the universe.)

The existence of the second set of absorption lines indicates that the M100 galaxy also has a corona. Co-

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ronas may be a characteristic feature of many galaxies; one that is too dim in visible light to be seen on telescopic photos but that can be detected by ultraviolet spectroscopy.

The third and most interesting feature Panagia found was a set of broad emission lines. These are bright bands in the spectrum, at wavelengths where electrically excited atoms emit their characteristic radiations. Emission lines were also noted in the visible-light spectrum of the supernova, but the ultraviolet emissions differed fundamentally from them.

Interpretation in terms of the Doppler effect showed that the visible-light emission lines are produced by atoms in a gas erupting with speeds as high as 6,200 miles per second, while the ultraviolet lines came from material expanding at the much lower (although still impressive) speed of about 2,500 miles per second. Further, the visible-light lines showed a deficiency of red-shifted light, corresponding to gas expanding from the supernova in the direction away from the earth, while the ultraviolet lines had no such deficiency. This difference was the main clue enabling Panagia to explain the different origins of the matter producing the visible and ultraviolet emission lines, respectively.

Panagia's explanation is as follows: the visible-light lines come from a region that, although expanding, is still relatively small. Small enough, in particular, so that the matter in this region on the far side of the central exploding star (and hence expanding directly away from the earth) is hidden by the star itself. This region is probably located just above the photosphere already mentioned. Since the rear hemisphere of the region is hidden by the star, it does not contribute light to the emission lines observed from the earth. Thus, there is not much red-shifted light in the visible emission lines.

On the other hand, the source of the ultraviolet emission lines is ascribed to a layer that is much larger in size than the photosphere. Since this layer is so big, only a negligible part of its rear hemisphere is hidden by the central star. Thus, the larger layer yields essentially equal amounts of red- and blue-shifted emissions. (Motion away from the observer produces red shifts; motion toward the observer causes blue shifts.) However, since the ultraviolet emissions indicate a smaller expansion velocity than the visible emissions, the slower-expanding layer, remarkably, is bigger than the fast-expanding layer.

If there had been only one stellar explosion, the fastest-moving gas would have traveled the farthest and would be on the outside, a situation exactly contrary to the above conclusion. There is no independent evidence for two explosions, however, and indeed no supernova has ever been seen to explode twice. This seeming dilemma can be reconciled with known properties of stars, even if we accept that there was only one explosion and it produced the more rapidly moving inner zone. The outer zone, the one that emits the ultraviolet lines, must consist of gas that left the star long before the explosion. If, as is generally thought, the previous state of a Type II supernova is a red supergiant star, the source of this outer zone material can be identified.

Red supergiants are notable for their steady streams of cool gas, which flow outward in the form of so-called stellar winds. The outer zone of the M100 supernova, expanding now at 2,500 miles per second, probably consists of gas carried outward in such a wind before the star exploded. The current expansion is proceeding at roughly 100 times the estimated wind speed, however, an important discrepancy that must be confronted. The most likely suggestion is that a burst of X-rays from the initial moment of the supernova explosion was absorbed in the wind material. This great pulse of energy compressed, heated, and accelerated the gas, producing the rapidly expanding zone that now shines brightly as a source of ultraviolet emissions.

This theory by Panagia remains to be proved. In particular, calculation indicates that the wind before the explosion must have carried off mass at a much greater rate than is commonly observed in red supergiants. Nevertheless, it does seem likely that the supernova has illuminated and excited material that left the same star in an earlier phase of its life. Future analysis may yield insight into the nature of the events that transpired as a massive star burned brightly and inexorably toward an explosive fate.

*Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.*

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# Celestial Events

by Thomas D. Nicholson

**The Moon** Evening moonlight doesn't show up until late in the second week this month, when the early crescent moon appears. The moon is new on October 8, first-quarter on the 16th, full on the 23rd, and last-quarter on the 30th. It will be new again on November 7 and first-quarter on the 15th. Apogee moon (farthest from the earth) is on October 9 and November 5; perigee (nearest the earth) on October 23. The full moon of October 23 is the hunter's moon. Since perigee occurs close to the date of the full moon, watch for exceptionally strong tides on October 23 and 24.

**Stars and Planets** During October, Jupiter joins Venus to become prominent in the morning sky. Venus isn't as bright and rises later compared to its performance last month. Jupiter, on the other hand, is steadily improving, rising earlier and appearing higher at dawn. The moon will guide you to Jupiter on the 7th, but after mid-month the planet stands high enough at daybreak to be seen easily. Jupiter rises later and appears lower than Venus all month, but the distance between them diminishes, and Venus catches and passes Jupiter at the end of October. By then, Saturn comes into view in the morning, lower than Venus and Jupiter and much dimmer.

During October, the sun moves through the stars of Virgo, passing into Libra on the 30th; Mercury moves out of Virgo into Libra early in the month, Venus moves from Leo into Virgo at the end of the month. Mars spends early October in Libra, about a week in Scorpius at mid-month, and the end of the month in Ophiucus. Jupiter and Saturn are in Virgo, Uranus is in Libra, Neptune in Ophiucus, and Pluto in Bootes.

October 4–5: Be sure to look for Venus, Regulus, and the waning crescent moon on both mornings, high in the east at dawn. Venus passes very close to Regulus at 11:00 A.M., EST, on the 4th, and the moon passes both between midnight and 1:00 A.M. on the 5th.

October 7: Jupiter is near the crescent moon early this morning.

October 12: Mars is well below the crescent moon until it sets.

October 21: Tonight (from 1:00 A.M. on) is best for hunting the Orionid meteors, about 25 per hour, but swift and often bright.

October 24: Mars and Antares (the bright red star of Scorpius) are in conjunction. Both are low in the southwest at dusk.

October 26: Communities on daylight time set clocks back one hour early this morning.

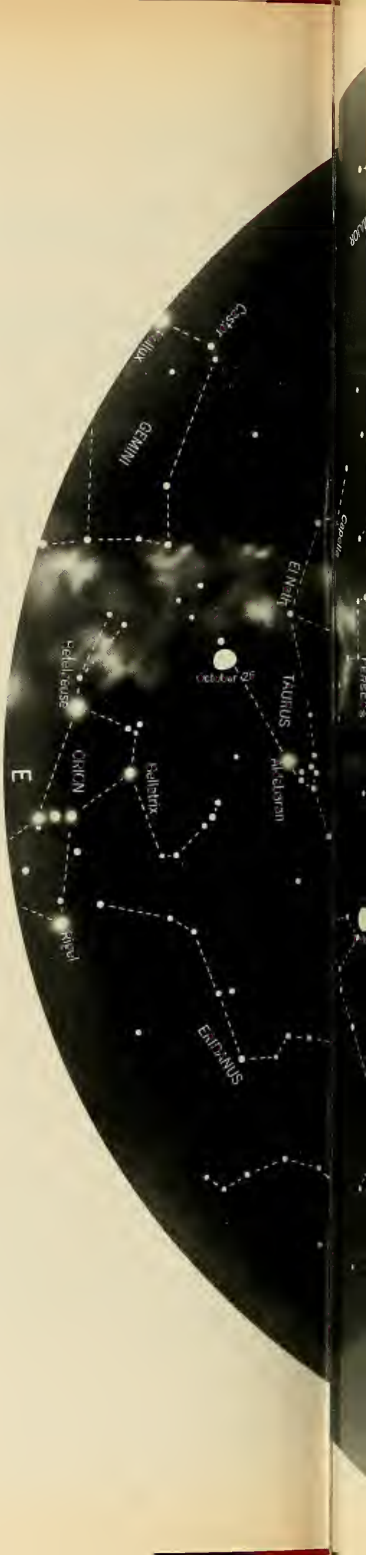
October 30–31: Be sure to look for Venus (the brighter) and Jupiter on both mornings, in the east at dawn. Venus passes Jupiter at about 3:00 P.M., EST, on the 30th. Saturn is below the two.

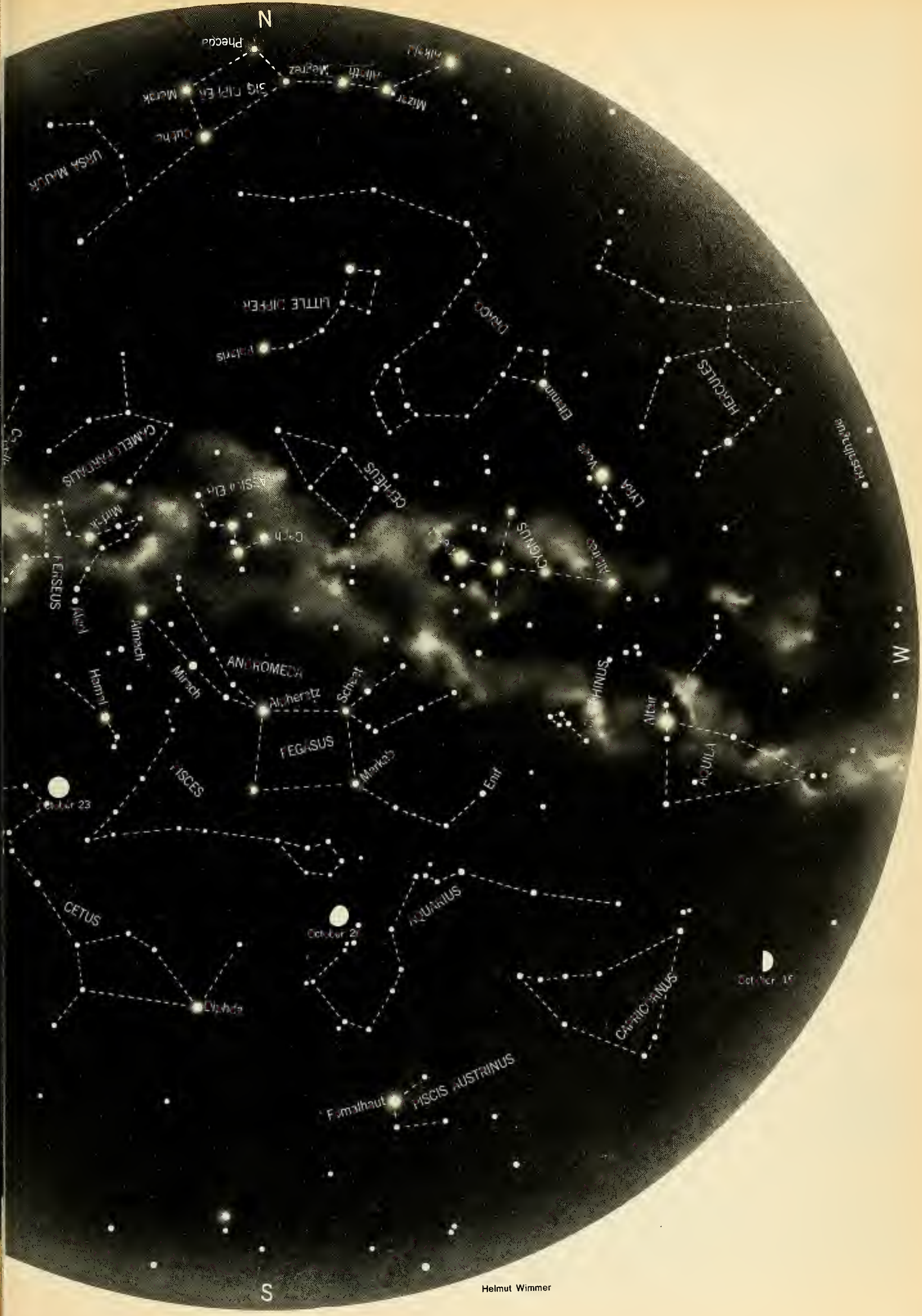
November 1–4: Try to watch the eastern dawn sky each morning these days, to see Venus move between Jupiter and Saturn, and the crescent moon pass Regulus, Jupiter, Saturn, and Venus in turn.

November 11: Mercury resumes its direct (easterly) motion as a morning star.

November 15–16: This is the night (from 1:00 A.M. on) for the Leonid meteors, the swiftest, brightest, and most famous of all meteors.

**Evening Star Map** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those in the sky. When you face the other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match the stars in the sky with those on the lower half of the map. The map represents the evening sky at about 11 to 12 P.M. on October 1; 10 to 11 P.M. on October 15; 9 to 10 P.M. on October 31; and 8 to 9 P.M. on November 15. It shows only planets and moon phases above the horizon at those times.

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Helmut Wimmer

# Little Finger Nail's Ledger Book

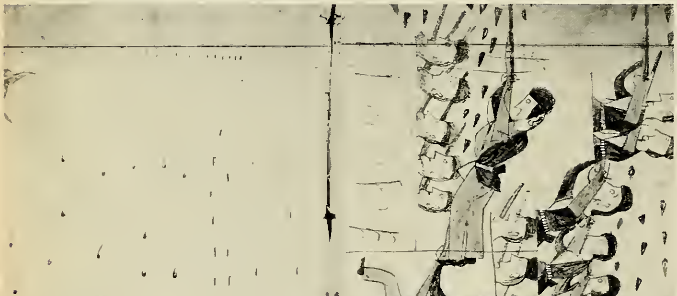
On display in the Hall of Plains Indians at the American Museum of Natural History is a ledger book covered with faded bloodstains. It has been pierced by a bullet that tore through its cover and shredded some of its pages. Inside are scenes of battle and courtship drawn by Little Finger Nail, a young Northern Cheyenne warrior, during the last months of his life.

This ledger was one of two given to the Museum in 1912 by the estate of Joseph Cuyler Hardie. Hardie's brother Francis, a cavalry officer during the Indian wars, had taken the bullet-pierced ledger from the body of Little Finger Nail following a battle. He sent the two ledgers to his brother with the following letter:

> Post of San Antonio, Texas
> Sept. 21, 1889
>
> Only the canvas covered book has any special history, the book with the bullet hole in it. It was, or rather the pictures were, drawn by a Northern Cheyenne Indian while in confinement at Fort Robinson, Nebraska during the winter of '78, '79. I was then Post Adjutant. I endeavored to get the book but its owner and maker refused to part with it for any price. So I gave the matter up. It purports to depict the deeds of several of the Northern Cheyennes during their famous march from the Indian Territory to Wyoming Territory. The outbreak of the Cheyennes is well known, and [as] a consequence of the outbreak, I got the book in this manner. Four troops . . . commanded by Captain Wessells, who by the way was severely wounded, surrounded the hostiles and charged upon them killing all the bucks and unfortunately in the melee, some women and children, but previous to the charge I saw an Indian with the book pressed down between his naked skin and a strap around his waist; another strap went between the middle of the book and around his shoulder. I turned to Private Laselle of H troop who was near me and said, "I want that book if we come out all right." Several others of the enlisted men heard me also. When the fight was over, and as the dead Indians were being pulled out of the rifle pit, they drew out finally my Indian with the book, apparently dead; the book was injured to the extent of a carbine ball through it and was more or less covered with fresh blood. This fight took place near Bluff Station, Wyoming Territory, January 22, 1879. This fight was the closing one of a series of fights with the Indians, and they perished to a man.
>
> In haste,
> Frank [Francis H. Hardie]

Ledger-book Indian art was not uncommon during the closing years of the Indian Wars. It supplanted to some degree earlier warrior art, which detailed the exploits of the warrior and his friends in paintings on the flesh side of buffalo hides and tepee covers. Ledger books, convenient and portable, could be carried into battle and were not likely to be destroyed by soldiers who often burned villages after surprise attacks.

Some warriors painted their own scenes, but more often a warrior would



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*To prove his courage, a Cheyenne warrior runs past a line of firing troops, a feat usually attempted if he had had a prophetic dream of invincibility. This drawing, probably made by a friend of the warrior, may depict one of several battles fought outside of Dodge City.*

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ask an artist in the tribe to outline the figures in paint, which the warrior would then color in. He would recount to the artist various incidents in his life, including details of specific battles—descriptions of horses, the number of troops, even the brands on captured horses and cattle. Early warrior art used paints made from ash mixed with buffalo blood (for black), or from different iron-bearing clays mixed with the gluey residue of hide scrapings (for colors). Pencils, crayons, ink, and watercolors obtained from traders quickly replaced the traditional paints.

The story of Little Finger Nail's ledger begins with the Northern Cheyenne's disastrous defeat at their camp on Crazy Woman's Fork on the Powder River. Gen. Ranald Mackenzie and his soldiers drove the survivors, including two great chiefs, Dull Knife (Morning Star) and Little Wolf, deep into the Bighorn Mountains. Suffering from frostbite and starvation after a bad winter in the mountains, the Cheyenne voluntarily surrendered at Fort Robinson in April, 1877.

They were at Fort Robinson for only a short time when the U.S. government, acting under the terms of a treaty the Cheyenne had signed in 1868 with General Sheridan, ordered the band moved south to Indian Territory. Outraged, Dull Knife and the other chiefs claimed that Sheridan must have lied to them about the terms of the treaty. Finally, under extreme pressure and with the promise that they could return if they didn't like the South, the Cheyenne acquiesced.

In August 1877, Dull Knife, Little Wolf, and their people arrived at the Darlington Agency, near Fort Reno, Indian Territory. Almost immediately, two-thirds of the tribe came down with malaria and other diseases. The water was bad and rations were scarce and foul. (Even Mackenzie protested to Washington, referring to the terrible conditions on the reservation as "starvation" and a "great wrong.") The Cheyenne told agent John D. Miles:

> We are sickly and dying here, and no one will speak our names when we are gone. We will go north at all hazards, and if we die in battle our names will be remembered and cherished by all our people.

At dawn on September 9, 1878, many of the Cheyenne, led by Dull Knife and Little Wolf, left the reservation and headed north. Thus began the famous Cheyenne march from Indian Territory to Wyoming Terri-

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tory—and also the events that Little Finger Nail recorded in his ledger.

Little Wolf, who had been fighting white men since 1856, warned his people, especially the young warriors such as Little Finger Nail, that they were not to fire at soldiers unless fired upon, and on no account were they to kill settlers or cowboys.

As they moved north, the Cheyenne were attacked again and again by soldiers. They fought them off when they could and retreated when they were outnumbered.

As they neared Dodge City, on the open Kansas prairie, they were again attacked, this time by soldiers and cowboys. Although the Cheyenne repulsed their attackers, Little Finger Nail and the other young warriors were angry and vengeful. Tired of restraint and in need of horses and food, they no longer listened to Little Wolf. The next day, some of them raided a cow camp, killed four whites, and captured some horses and mules. They continued to raid settlements north of Dodge City, especially along Sappa and Beaver creeks, where buffalo hunters and soldiers had massacred Cheyenne women and children thre years before. In retaliation for thos killings, Little Finger Nail and hi friends shot exactly as many whit men as the whites had killed India men. And in one raid, they capture more than 200 horses.

Little Finger Nail recorded man of these events in his ledger book Some scenes depict the raids and th frequent encounters with troops: w see drawings of a warrior gallopin through a hail of bullets, a young ma on a spotted horse counting coup o a fallen settler, a camp of buffalo hunters, a smiling warrior galloping of with stolen U.S. Cavalry horses, an a major battle with entrenched soldiers (possibly one of several nea Dodge City). We know that most o the warriors are young because thei clothing is unadorned and their shirt are of white manufacture. Scattere among the battles and raids are scene of love and courtship.

The second ledger, drawn by an unknown Indian, probably records th same raids, and even includes th name glyphs of the warriors involved Our only clue to who created this sec

**Film Festival**

On Saturday and Sunday, October 4 and 5, the 1980 Margaret Mead Film Festival will feature ethnographic films and discussions with filmmakers and anthropologists. Special programs in this year's festival include premières of four films on the People's Republic of China and films and discussions on Iran. Weekend programs are free, and film schedules may be picked up at Museum entrances. (See "At the American Museum" in last month's *Natural History* for details.)

**Witches, Goblins, and Ghosts**

To mark Halloween, storytellers Laura Simms, Jackie Torrence, and others will spin tales of ghosts, demons, and a host of supernatural beings from around the world—from Asia and Africa to the deep South. The program, which is free to members, $3.00 for nonmembers, will be presented in the Education Hall on Sunday, October 26, at 11:00 A.M., 1:30 P.M. and 3:30 P.M.

**Classical Indian Dance**

Indrani and her daughter Sukanya will perform classical Indian dances in the Auditorium on Wednesday, October 29, at 7:00 P.M. The free program includes selections from two of the major traditions, Bharata Natyam and Orissi.

**Asia Live**

Live programs and lecture-demonstrations of dance, music, and crafts of Asia will be presented in the People Center on weekends in October and November. On October 18 and 19, India is the featured country, and on October 25 and 26 and November 1 and 2, Japan.

**Asia on Film**

On October 18 and 19, four films on India will be shown in the Auditorium from 2:00 to 4:00 P.M., including *Kishan and the Magic Chariot*, about a boy and his schoolmaster, and *From the Ocean to the Sky*, about adventurers who journey up the Ganges by jet boat. On October 25 and 26, *Full Moon Lunch* and *Farm Song*, two John Nathan films that look at two different sides of traditional Japan, will be screened. All films are free.

**Books on Asia**

An exhibit of books, some quite rare, used to research and design the new Gardner D. Stout Hall of Asian Peoples, ond ledger is the frequent repetition of a name glyph that looks like a humpbacked buffalo, and we know that one of the young Cheyenne was called Bull Hump.

After crossing the South Platte River on October 4, 1878, Little Wolf and Dull Knife disagreed on where to proceed. Dull Knife wanted to go to the Red Cloud Agency where he thought the Sioux were. Little Finger Nail and part of the band joined him, while Little Wolf headed north.

On October 23, Dull Knife's band was surprised by soldiers during a blinding snowstorm and taken to Fort Robinson. Along the way, they took apart their best rifles and pistols and hid the pieces among the clothes of the women and children.

At Fort Robinson the Cheyenne had a lot of free time and were given the run of the camp. Here Little Finger Nail drew many, if not all, of the scenes in his ledger; the other ledger was probably also created at this time.

All went well until the soldiers discovered that Bull Hump was missing. The Cheyenne were immediately confined to their barracks, and remained

will be on display in the Library Gallery beginning in mid-October.

**The Planets**

*The Planets*, an exhibit of the gold- and silver-wire designs of Raoul Lametz, opens at the Hayden Planetarium on October 1. This artist has incorporated astrological symbolism and scientific data in his renderings of the various planets of the solar system.

**Discovery Tours**

Thomas D. Nicholson, director of the Museum, and six other Museum and guest lecturers will lead a cruise of the waterways of western Europe in late June 1981. Major land excursions will explore Barcelona, Granada, Seville, Lisbon, Santiago de Compostela, La Rochelle, Brest, Mont St. Michel, and Rouen. This is the sixth Museum cruise aboard the m.t.s. *Orpheus*, arranged with Swan Hellenic Travel of London. Other cruises have visited the Black Sea, the Adriatic, the Mediterranean and North Africa, and Egypt and Israel. Nicholson, with Swan, has created a new itinerary that will visit archeological sites, zoological sanctuaries, and other places of interest. For information on the 1981 Museum travel program, write to Discovery Tours at the Museum.

American Museum of Natural History
Discovery Tours

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prisoners even after Bull Hump returned a few days later. Meanwhile, Capt. Henry Wessells, the commanding officer, received orders that the Cheyenne were to be sent south immediately. When Dull Knife heard this, he said:

> All we ask is to be allowed to live, and to live in peace. I seek no war with anyone. An old man, my fighting days are done. We bowed to the will of the Great Father and went far into the south where he told us to go. There we found a Cheyenne cannot live. . . . To stay there meant all of us would die. . . . We thought it better to die fighting to regain our old homes than to perish of sickness. Then our march was begun. You know the rest.
>
> Tell the Great Father that Dull Knife and his people ask only to end their days here in the north where they were born. Tell him we want no more war. . . . Tell him if he tries to send us back we will butcher each other with our own knives. I have spoken.

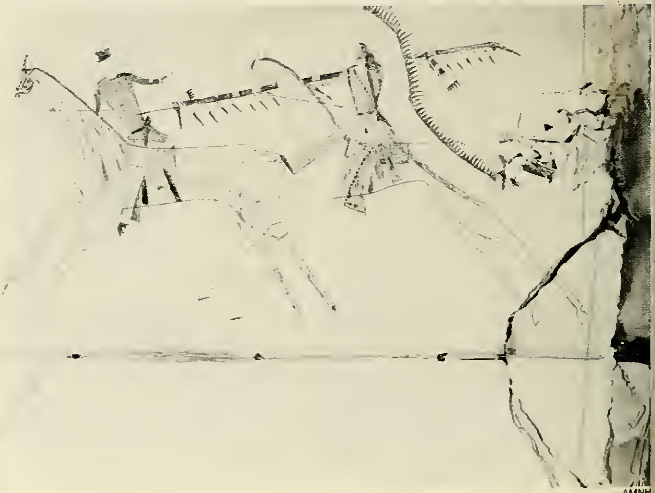
Wessells relayed Dull Knife's message to Washington and received the following reply from General Sheridan: "Unless they are sent back to where they came from, the whole reservation system will receive a shock which will endanger its stability." When Dull Knife was told of Sheridan's response, he said: "Great Grandfather sends us death in that letter. You will have to kill us and take our bodies back down that trail. We will not go."

Wessells responded by cutting off all food, fuel, and water to the Indians locked in the barracks. A few days later, on January 8, 1879, the Cheyenne covered the windows of the barracks with blankets, ripped up the floorboards to make clubs, and assembled twelve rifles and three pistols from the pieces they had previously hidden. Thinking something might be up, Wessells increased the guard and had a blacksmith wrap chains across the locked doors. During the evening of January 9, the Cheyenne put on their war clothes and painted their faces. Little Finger Nail strapped his ledger around his waist and secured it with a second strap that passed through the middle of the book and around his shoulder.

At 9:45 P.M., Little Finger Nail and another young leader smashed two windows and started shooting, killing the sentries at the southwest and western ends of the barracks. Within seconds, the other warriors opened fire on the guards. Men, women, and children began pouring through the broken windows. As the Cheyenne fled across the snow-covered prairie in the bright moonlight, the soldiers piled out of their quarters and fired away at the fleeing figures, killing about half, including some of the slower women and children. Wessells sent the cavalry in pursuit of the rest.

Little Finger Nail and a small band

*This drawing in Little Finger Nail's ledger book shows a warrior attacking a soldier. Damage, at right, was caused by a bullet.*



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of people made it across the White River and headed southwest into a series of bluffs behind the camp, then veered northwest. They had no horses, little food, and scant clothing. During the days that followed, the Cheyenne tried to shake the soldiers from their trail, with no success.

Finally, thirteen days after the escape and only thirty-five miles from Fort Robinson, they realized that escape was hopeless and decided to dig in to meet the soldiers in battle. Uncharacteristically, they chose a poor defensive position—a dry streambed at the edge of the bluffs. The soldiers had a clear line of fire, and the Cheyenne did little to conceal their presence, although they did pile up frozen sod and try to chip out rifle pits in the earth.

The pursuing soldiers, Frank Hardie among them, quickly discovered the hide-out. As Hardie mentions in his letter, he was close enough to pick out Little Finger Nail before the battle. The cavalry charged to the edge of the washout again and again, firing into the scattered shrubbery, the rifle pits, and the crude breastworks that hid the Cheyenne. For an hour, the vastly outnumbered Indians—thirty-one men, women, and children—fought with the few guns and ammunition they had. When all was silent, Wessells and the troops moved up the edge of the washout and gazed at the bodies scattered about. Suddenly, a warrior raised his gun and fired at the captain, hitting him in the head. The soldiers immediately resumed the attack. After firing at the bodies in the hollow for about fifteen minutes, they again paused, but within moments three bloody warriors leaped up and armed with only two knives, charged the soldiers. The soldiers promptly shot them down.

Once more the nervous soldiers crept to the edge of the washout. Only a few women and children were alive; most were badly wounded.

When the soldiers had hauled the last of the bodies from the washout, Hardie untied the ledger book from Little Finger Nail's body. He carried it with him for ten years until 1889, when he sent it east to his brother. The Museum, which received the ledger in 1912, put it on display in the Hall of Plains Indians in 1934. It remains there today, a Cheyenne warrior's account of the last days of his people.

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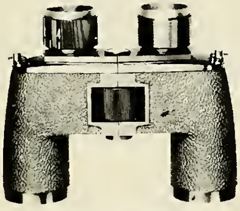

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# Additional Reading

**Moose** (p. 38)

D. Allen's *Wolves of Minong: Their Vital Role in a Wild Community* (Boston: Houghton Mifflin Co., 1979), a semitechnical treatment of the classic Isle Royale moose–wolf study, includes information about moose behavior and ecology. A classic in the field, E. O. Wilson's *Sociobiology: The New Synthesis* (Cambridge: Harvard University Press, 1975) treats animal behavior from one sociobiological perspective. Discussion of the multiple equilibria/catastrophe theory and a review of new ideas and applications of systems ecology can be found in *Adaptive Environmental Assessment and Management*, edited by C. S. Holling (New York: John Wiley and Sons, 1978). E. C. Zeeman introduces catastrophe theory in an article in the April 1976 issue of *Scientific American*, pp. 65–83, and presents the subject more thoroughly in *Catastrophe Theory: Selected Papers (1972–1977)* (Reading: Addison-Wesley Publishing Co., Inc., 1977).

**Opium Poppy** (p. 52)

Although most available literature on the opium poppy deals mainly with social aspects of the plant as a source of opium and opium derivatives, the United Nations Division of Narcotic Drugs (Vienna International Center, P. O. Box 500, A-1400, Vienna, Austria) publishes material on nonnarcotic uses of the poppy, which they will furnish to people who write for it. The June 1950 issue of their *Bulletin on Narcotics* (vol. 2, no. 1, pp. 13–25) contains a detailed description of the cultivation of the plant in Turkey as practiced before the 1971–74 ban. "A Survey on the Factors Preventing Opium Use by Poppy Growing Peasants in Turkey," by Alâeddin Akcasu (vol. 28, no. 2, 1976, pp. 13–17), explores the phenomenon of opium avoidance in rural Turkey. The Division's pamphlet, *The United Nations and Drug Abuse Control* (1976), summarizes the development of the international drug control system.

**Stromatolites** (p. 58)

*Stromatolites* ("Developments in Sedimentology 20"), edited by M. R. Walter (New York: Elsevier Scientific Publishing Co., 1976), is a collection of articles explaining the present and past distributions of stromatolites and their morphogenesis, with a complete bibliography. This book includes "Modern Algal Stromatolites at Hamelin Pool, a Hypersaline Barred Basin in Shark Bay, Western Australia," by P. E. Playford and A. E. Cockbain and "Stromatolite Morphogenesis in Shark Bay, Western Australia," by P. Hoffman.

**Anteaters** (p. 62)

Two of G. Durrell's books describe his encounters with giant and pygmy anteaters. *Three Tickets to Adventure* (New York: The Viking Press, 1955), a record of the author's animal-collecting trip to British Guiana (Guyana) in 1955, includes photographs of anteaters. One chapter of *The Drunken Forest* (New York: Penguin Books, 1958) describes the adventures of Durrell and his wife in rearing a baby giant anteater. For a scientific account of anteaters, see "Prey Influences on Movements of Neotropical Anteaters," by G.G. Montgomery and Y.D. Lubin in *Proceedings of the 1975 Predator Symposium*, edited by R.L. Phillips and C. Jonkel (Missoula: University of Montana, 1977). G. Montgomery is currently editing a comprehensive book on the biology of the Xenarthra to be published by the Smithsonian Institution Press.

**Indian Photos** (p. 68)

R.B. Hassrick's *The George Catlin Book of American Indians* (New York: Watson-Guptill Publications, 1977) contains reproductions of nearly half of Catlin's American Indian paintings. J. Ewers analyzes Catlin's work and that of others in "George Catlin, Painter of Indians" (*Smithsonian Annual Report for 1955*, pp. 483–528). J. Scherer discusses photography of American Indians in *Indians: The Great Photographs That Reveal North American Indian Life 1847–1929, from the Unique Collection of the Smithsonian Institution* (New York: Crown Publishers, Inc., 1974) and in "You Can't Believe Your Eyes: Inaccuracies in Photographs of North American Indians" (*Studies in the Anthropology of Visual Communication*, Fall 1975, pp. 67–79).

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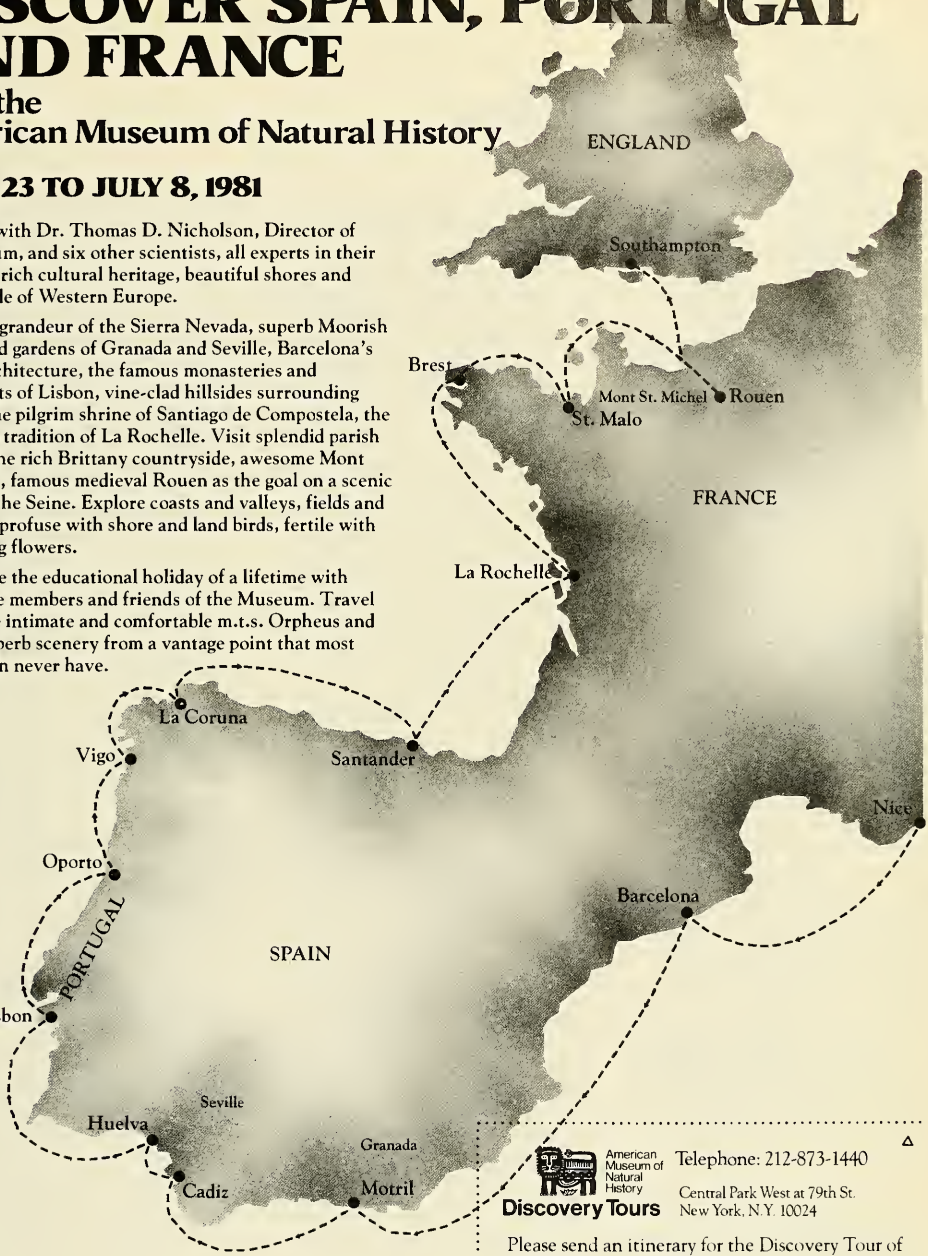
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# Soviet Intervention

**by David E. Powell**

THE DESTRUCTION OF NATURE IN THE SOVIET UNION, by Boris Komarov. *M.E. Sharpe, Inc., $15.00; 160 pp.*

This is an extraordinary book. Its author, identified only as "a ministry official who continues to live in the Soviet Union," demonstrates a breadth of knowledge so vast, a sense of moral outrage so profound, and a gift for language so acute as to make *The Destruction of Nature in the Soviet Union* a landmark in our understanding of environmental problems in the USSR.

Readers of *Natural History* are doubtless aware of the damage already done to Lake Baikal in Siberia, and some may even know about the threatened extinction of certain species of animals found only in the most remote corners of that country. But few readers are likely to be informed about the extent of environmental degradation in the USSR, and fewer still have had access to information about the political, economic, and ideological factors that have given rise to this tragic state of affairs.

To be sure, there are now a fair number of English-language books and articles devoted to environmental problems in the USSR: studies by Keith Bush, Cynthia Enloe, Marshall Goldman, Donald Kelley, John Kramer, Philip Pryde, and Fred Singleton. Until the publication of this book, however, no Soviet author had put together a comprehensive study of air and water pollution, land depletion, and the destruction of wilderness and wildlife in that nation. We are in debt to Mr. Komarov (a pseudonym, of course, since this is a *samizdat* work). He has been well served by his translator, who is faithful to the style and tone of the original—somewhat rambling, often witty, and always impassioned. Marshall Goldman has added a brief, but useful, introduction.

While Western specialists on the USSR will be uneasy because only some of what Komarov says is documented, his general argument has the clear ring of authenticity. It is also consistent with what I (and others) have learned from Soviet scholars, journals, and other Soviet sources.

Komarov devotes two chapters to environmental disruption in Siberia. One chapter focuses on the Baikal episode, describing the "moral," as well as the ecological, harm associated with the construction of two huge pulp and paper combines on the lake's shores. The author speaks eloquently about "the deadly peril that is accumulating gradually and silently, like an avalanche, in the depths of Baikal." Purification equipment, belatedly installed after expressions of outrage were heard from Soviet scientists and concerned citizens abroad, works poorly and has only slowed the pace at which damage is occurring. In Komarov's words, "it merely transformed wholesale pollution into pollution of Baikal in installments."

He is appropriately critical of prominent scientists who were willing to go along with this shortsighted policy, men who rationalized their decisions in the most crude and cavalier manner. Consider, for example, A.P. Vinogradov, the vice-president of the USSR Academy of Sciences, who summarily rejected a report by a panel of experts recommending that the project be abandoned. "You mention that the Baikal combines will prove fatal to the lake," he declared. "But how can this be? The government decides to build, and you say 'impossible. . . .' Take your report and do some more work on it." The argument of a second academician was even more primitive. "Why are we going on so about this Baikal?" he asked. "Pollute it if we have to. Now we have nuclear energy, and if later we have to, we can easily make Baikal again." (It should be noted that the damage to Baikal did not end with the construction of the two plants. The Baikal-Amur mainline being constructed in Siberia has already added to the lake's distress and will do even more harm in the future. According to Komarov, "Gasoline, diesel fuel, grease, and other petroleum products from every settlement's workshops, garages, and railroad car depots gather drop by drop, trickle by trickle, stream by stream into a constant, black petroleum tributary of Baikal.")

Other parts of Siberia have also sustained environmental damage on a scale that can only be termed "Siberian." For many kilometers around villages, Komarov reports, "there is neither a tree nor even a bit of natural landscape—only littered, swampy wasteland where heaps of ash, slag, bottles, other rubbish, and the hulks of cars and trucks abound." Furthermore, because so much energy is used to heat modern apartments in this frozen land, the air above many settlements has been "gravely affected," and nearby territories suffer even greater harm. "Ten months of smoky atmosphere, filthy snow, and dirty meltwater kill all the moss and lichen in the surrounding area. . . . Deprived of its covering . . . the permafrost quickly turns into swamp."

Other chapters offer no more grounds for optimism. In the chapter that deals with air pollution, for example, readers will learn about the Soviet city that has had to set up a special brigade of workers to clear away, every three months, the dirt and soot that accumulate on rooftops throughout the city. (If this step were not taken, the roofs would collapse.) In addition, the air over the Siberian city of Bratsk regularly contains levels of carbon monoxide, sulfur dioxide, and other gases far above those considered safe. As a result, "the taiga around Bratsk, to say nothing of the green areas within the town limits, is rapidly withering. One hundred percent of the seedlings are dying."

A chapter on water pollution focuses on PCBs, petrochemical wastes, DDT, heavy metals (such as mercury, cadmium, and lead), and other substances familiar to American environmentalists. Komarov notes that the Sea of Azov, once "famed for its fantastic catches of sturgeon, carp and perch," has become "a latrine . . . for the industrial south of Russia and the Ukraine." He compares the damage to Azov with that to Lake Erie in the United States. "Here, at Azov, we have caught up with America. And gone ahead, since Erie was never the nation's marine larder, as was Azov." Some rivers, he also notes, "have been turned into sewers."

Komarov's account of the wanton destruction of wildlife in the USSR is especially depressing. As readers of the Soviet press know, the country's nature preserves, where wildlife is supposedly protected and hunting strictly forbidden, are regularly violated by Communist Party, government, and military officials—"the very pillars of society," as Komarov contemptuously calls them. There is a chilling description of a hunt in the Kyzyl-Agach Preserve in Azerbaijan organized by Marshal Chuikov and his fellow officers. "Early in the morning the marshal, his adjutants, and the entourage drove onto the preserve in a whole column of all-terrain vehicles." After shooting hundreds of ducks, geese, and other birds, Chuikov transferred to a helicopter: ". . . circling over the reed banks and spotting a herd of wild boar, he began shooting at them with his automatic rifle."

Even more grotesque is the training technique developed by military officers stationed in the Baikal area. For many years, they have given their men practice in the use of ground-to-ground, heat-seeking missiles by having them fire at wild boar and deer on the run. "Startled by the sound of a shot, the animals dash across wooded hills, and the accurate rockets overtake them wherever they go."

*The Destruction of Nature in the Soviet Union* is obviously the product of careful research; it combines the virtues of "insider" reporting, serious reflection, and vigorous scientific analysis. At the same time, it is a *cri de coeur*, a passionate statement of protest by a man who loves his country, who is deeply moved by its natural beauty and proud of its abundant resources but horrified at what the government has done in the name of "progress," "military security" and "the national interest."

He expresses particular anger at the dishonesty of official propaganda, which blandly denies the possibility of any serious threat to the environment in a "socialist" state. "To create the illusion that existing economic and ideological means are sufficient to deal with the problems of ecological disaster, or that the current course of the economy can steer the country away from the reefs and shoals toward which other countries are drifting," he writes, "is the gravest sin of Soviet propaganda. A sin unforgivable in its consciousness and premeditation."

One can only be saddened by all this, for the Soviet leadership has wasted a golden opportunity to preserve and enhance nature's gifts. The USSR is less advanced economically than the West and thus can profit from our mistakes. The Soviet political elite claims to be guided by the lofty ideals of "socialist humanism." The State owns all the land and the means of production, and the Communist Party can impose its will on all individuals and organizations throughout the country. In view of these circumstances, we might have expected the USSR to be safe from the depredations of "robber-baron" industrialists and other despoilers of nature.

However, as the Soviet experience demonstrates, centralized decision making and the capacity to mobilize the energies of the entire population have not always led to socially desirable ends. Socialist industrialists, no less than their capitalist counterparts, have shown themselves capable of despoliation on a massive scale. Indeed, centrally determined priorities, allocations, incentives, rewards, and punishments have been harnessed to an almost pathological fixation on production, at the expense of all else. Today, ecological concerns remain a "luxury" that the Soviet leaders—like their counterparts almost everywhere in the "civilized" world—simply cannot understand.

*David E. Powell is a research fellow at the Russian Research Center and a lecturer on government, both at Harvard University.*

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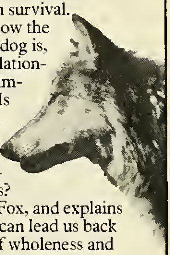

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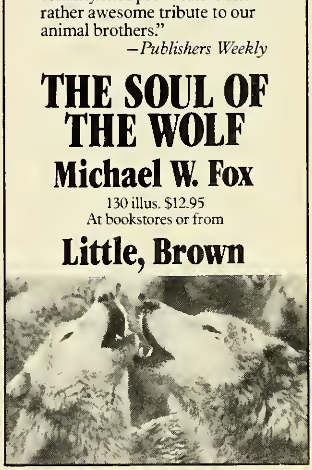

# Fleece Afoot

*Herds of sheep grow fat on the cool green grasses above timberline*

**by Raymond Sokolov**

Way back up in the hills, high above the Colorado River, high above the tourists in rafts and kayaks, but less than fifty road miles from Doc Holiday's Bar in Glenwood Springs, with its Old West trappings and mean-mouthed barmaid, you get to the top of an anonymous mountain in the White River National Forest and turn left through the aspens and Engelmann spruces onto a dirt track they call the Bar H-L Road. You'd better go in with a four-wheel drive, because when it rains, the gradually descending trail, marked with U.S. Department of Agriculture Forest Service mileposts, can turn to quagmire. On a dry day in early July, maybe ten miles after the turn and just as you are getting used to the bumping ride and the lush, fabulously expansive meadows, spattered with flowers and empty against the big sky, you hear the noise, as loud as a city of untuned bells or a jungle of monkeys.

Five thousand sheep are on the march up to their summer pasture where the grass stays cool and green. They are heading along an official stock driveway, through cattle-grazing country to higher pasture where only sheep can survive, for a two-month session of nomadic fattening. Ewes and lambs bleat as they walk—mothers trying to find their babies, babies separated from their mothers calling out, and eventually, since each animal has its own special bleat, they locate each other, bounding through the flock and then, always moving, the lambs "mother up" joyfully on the ewes' teats. The flock trudges on, guided by instinct but also shooed forward by shepherds on horseback and little dogs that keep the sheep from straying off into the woods. The herders whistle and hoot and head off the ragged edges of this woolly white mob. The flock flows over the tan road like a huge, low cloud.

Idyllic? Why of course it is. Theocritus coined the word *idyll* for his bucolic poems, which for the first time in Western literature described just such a scene. All pastoral poetry hymns the life of the shepherd (Latin *pastor*). And this procession of lonely men and gregarious animals (Latin *grex*="herd") from low pasture to high, this transhumance, is older than literature, older even than settled agriculture and the sedentary life we call civilization. But even the ancient tradition of the pastoral contained a darker strain, epitomized by the famous Latin tomb inscription that crops up in pastoral paintings by Guercino, Poussin, and Reynolds: *Et in Arcadia ego*, "Even I [death] am in Arcadia," the mountainous traditional haunt of Greek shepherds in the Peloponnesus.

And even in late twentieth-century Colorado, mortality lurks behind the peaceful and picturesque surface of the annual sheep drive. Nobody knows this better than Gus Halandras, whose survival as a sheepman is threatened by forces far more complex than the natural risks that menaced the pastoral livelihood of his Greek ancestors Thyrsis and Corydon in Arcadia.

On the surface, Halandras and his five thousand sheep are doing fine. He and his wife, Christine, both of them children of Greek immigrants, live in a big house in Meeker, Colorado, and raise fat sheep on open rangeland. But like all other American sheep producers, the Halandrases o erate in what might be called a hostil environment. The statistics are el quent.

In 1979, the national sheep floc numbered 12.5 million animals, mere fifth its peak size of 56 millio in 1942 and only a quarter what th flock was at the time of the first U.S sheep census in 1867, when the huma population was under 40 million. Las year's lamb slaughter yielded only 29 million pounds or 1.6 pounds per pe son. Compare this to an annual bee gorge of 120 pounds per capita an you have to conclude that lamb i relatively speaking, an endangere species.

Ironically, in the eleven wester states where 60 percent of America' sheep are raised, mostly on open range virtually no lamb is consumed. Th South is also a desert for lamb. Two thirds of American lamb is shippe to the Northeast, half of that to th New York City metropolitan marke where people of Mediterranean an Jewish background persist in buckin the national trend toward an all-bee meat diet. Gus Halandras says tha 90 percent of his lamb goes East.

No one, however, can say for sur why Americans don't all love lam with the fervor of Greeks and Jews Halandras speculates that a whol generation of GIs were subjected t bad Australian mutton during Worl War II and afterward wouldn't touc so much as a lamb chop. Then ther is the fact that beef cattle were con venient machines for gobbling up th postwar grain surplus and turning i into cheap, easy to prepare meat, whil most sheep continued to eat plai

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grass. Not only that; Americans who did indulge in lamb limited their consumption to the most expensive cuts, the chops and the leg. As a result, lamb has an expensive image, although these days the average price "across the carcass" is running about $2.50 per pound, as compared with $2.33 for beef.

To help educate the American consumer about efficient use of the whole lamb in cooking, Christine Halandras recently compiled a booklet of recipes for the American Sheep Producers Council (see recipes below). She is a skillful advocate of lamb consumption from tripe to head and has even taken to preparing Rocky Mountain oysters (lamb testicles) in an ingenious if improbable modern manner. Oysters are normally very hard work to clean, but as delicate as sweetbreads when breaded and fried. Mrs. Halandras drops them in her garbage disposal, which miraculously removes the tenacious mucous coating and leaves a perfectly white and unharmed oyster.

On the trail, she cooks more conventionally, but with a practical brilliance that made me think of pioneer women improvising meals out of their Conestoga wagons. In fact, the home economics of cooking for thirteen people in a modern sheep camp are not too different from pioneer conditions. For five days on the trail, the Halandras family, their two herders, and their guests all live in two tents and two metal-clad, homemade vehicles called sheep camps. Jim Atencio and Tomás Magaño, the herders, normally live by themselves in the camps, which look like gypsy wagons with stovepipes coming out of the roofs. Years ago, the ancestors of today's camps had long-spoked wooden wheels and were pulled by horses. In our time, pickup trucks do the hauling and the camps roll on inflated rubber tires. Otherwise, inside the camps, history stands still.

Ingeniously fitted out with wood bunks and a slide-out tabletop, as well as cupboards and stowage compartments, the Halandras camps reminded me of ships' cabins. The kitchen area, near the doorway, centers on a cast-iron wood stove, fired by fallen timber picked up along the way. On its surface and in its little oven, Christine Halandras managed to turn out impeccable pancakes, hot biscuits, and eggs with chopped venison. One day, she made a lamb stew from "rough cuts" that Gus Halandras sliced off the partly butchered yearling lamb he had slaughtered just before they left. The meat kept remarkably well in an unrefrigerated screened box. Year-old lamb is technically mutton, but this meat was tender and very flavorful, not muttony. The stew simmered during the midday break and then had to be hauled inside the camp to the place where we were going to spend the night. To keep the stew from spilling, Mrs. Halandras put the pot in a big metal washbasin. Barely a drop splashed out along the way.

On another night, we ate wheat tacos rolled out that afternoon by the Mexican herder, Tomás, and filled with venison chili. And at every meal, there was something produced in Christine Halandras's canning kitchen back in Meeker, where she puts up two thousand jars of spicy pickles and peach jam and tomatoes in a good year. At breakfast, for instance, she brought out some cherry syrup, a sweet-and-sour concoction she makes from the juice left in the large containers of pitted cherries she buys from a ladies aid society.

The whole family collaborated on these meals, feeding the stove, chopping, and peeling. Gus Halandras turned out to be a mean egg fryer, and his smoked mutton, sliced for an afternoon snack, was as sophisticated a use of a normally maligned meat as you could imagine.

All this cooking takes place in the middle of the day, while the sheep are grazing, waxing fat and not exerting themselves in the full sun. The herders rouse them at 5:00 A.M., while it is still cool, nudging the flock from behind to get the animals moving in the right direction, herding them along the road for a couple of miles or so, then resting them until 4:00 P.M., when they move them on for a similar distance and then stop them for the night. The pace is slow and orderly, to save the sheep's energy and prevent injury or loss. And all the way along the Bar H-L Road—which follows the migrational path of earlier nomads, the Ute Indians—other flocks belonging to other ranchers are ambling, in a federally controlled order of march, up to their grazing allotments on Forest Service lands.

This system was set up by the Taylor Grazing Act of 1934, which established firm official control of grazing on public lands. The Forest Service now regulates which sheep go where and when, in order to eliminate trampling of pastures still wet from spring runoff and to prevent the overgrazing that once exacerbated the traditional enmity between cattle and sheep producers all over the West.

Plenty of grassland is required in rough country above eight thousand feet to pasture sheep adequately. In the old days, free-ranging herds left wastelands behind them and earned the name "hoofed locusts" from cattlemen who retaliated by shooting whole flocks or driving them off cliffs. Under the modern system, which he finds overregulated and costly, Gus Halandras pays $2,700 for grazing rights on twenty thousand acres of USDA forestlands in the summer. In the winter, he uses sixty to seventy thousand acres of desert controlled by the Department of the Interior's Bureau of Land Management. Halandras has been driving sheep to these pastures for thirty years, and before him, his father had the same allotments. Understandably, he feels possessive about the vast meadows and resentful when bureaucrats regiment his drive.

photograph by Adelaide De Menil

Federal regulation is a rich topic of embittered discussion at the Halandras camp during the leisurely middays of the drive. Not only do the authorities control grazing, they also hinder Halandras's ability to import experienced herders. At the moment he has the men he needs. Jim is a U.S. citizen and Tomás has a green card that permits him to come in legally from Mexico to work most of the year in complete isolation, thousands of miles from his wife and children in the state of Michoacán. Few Americans are willing to endure a shepherd's solitude and fewer have the training necessary to supervise sheep. And the immigration laws are a roadblock in the way of sheep producers who want to import experienced shepherds on a permanent basis.

From Halandras's point of view, an even more galling threat to his kind of traditional mountain grazing comes from environmentalists who, at their most radical, want to keep sheep out of public lands altogether, protecting the fragile alpine ecology from everything human except perhaps a controlled form of tourism. "What could be more sensible, environmentally, then open range grazing?" he asks, while loading four orphan "bum" lambs, which have to be bottle-fed, into his overloaded pickup. "It takes no grain, no supplementals. We produce prime meat with grass feed. Is this country so affluent it can abandon a renewable resource and keep it just for recreation?"

Later, after a bath in a stream, Halandras fulminates some more against meddling wildlife preservationists who don't share his hatred of the coyote. Like other sheep producers, Halandras would like to use poison to control the coyotes, which, according to him, kill 10 to 15 percent of his lambs. But since 1972, when President Nixon ordered a ban on predator poisons on public lands, sheepmen have had to depend on traps, guns, and guard dogs. Last year, Jim Atencio did manage to trap or shoot sixty-three coyotes, but the Halandras flock still lost 250 to 300 lambs, "maybe more." Assuming that those figures are accurate, the loss from predation (figuring each lost lamb as a lost market potential of $70) ran Halandras from fifteen to twenty thousand dollars.

Environmentalists hotly dispute the standard figures that sheep producers give for their predator losses. And since most of the data available from official sources comes from possibly self-serving questionnaires solicited from sheep producers, it is hard to prove that the apparent rise in coyote-caused lamb deaths since the poison ban is a real one. Furthermore, the figures can be read in two ways.

Even if the percentage of predator kills has doubled since the 1950s, the rise could be explained simply as an arithmetical result of the decline in absolute numbers of sheep on open range pastures. If, for instance, the number of kills remained constant over time, the percentage loss would rise inevitably as the sheep population fell for a host of unrelated reasons, ranging from producers going into other lines of work to adverse market pressures. Obviously, coyotes do kill lambs, but the coyote controversy will never be resolved until a very thorough and disinterested study is made of coyote populations and the cause of lamb deaths on the range. Meanwhile, sheepmen seem to be fighting a losing battle against both *Canis latrans* and environmentally minded lawmakers.

The political weakness of sheep producers is, however, easily explained by their small numbers, distance from Washington, and lack of economic significance. And underneath all of these factors lies the fundamental stigma that sheep and sheepmen bear, both out West and in all America's folklore. As Halandras puts it, "No American child ever plays shepherds and Indians."

Gus Halandras hopes his own children will get out of the sheep business. "I want them to get an education," he says, "and train for a profession." Regas Halandras, fifteen, plans to become a lawyer. He and his younger brother are both accomplished herders, but if they sell their father's sheep and go to work in offices, their children will never know about the splendidly familial, outdoor, gypsy way of life on the range.

Perhaps open range grazing is an anachronism and a threat to the pristine quality of the western mountains. But it is still a vigorous tradition, locally symbolized by the initials that generations of herders have carved on aspens at campgrounds along the Bar H-L Road and nationally represented by meltingly tender domestic lamb raised on grass and thin air.

Unfortunately, through some Gresham's law of meat marketing, beef seems to have driven lamb virtually out of circulation. Lamb production rose slightly this year, but the basic picture is still dim. Regas Halandras knows that. His family may eat ground lamb, but MacDonald's doesn't serve it. And he must have learned another lesson about the low status of sheepherding when he went up to the edge of the family grazing allotments, at glorious Meadow Lake, and found the access road blocked with a log and posted with a sign forbidding automobile traffic. The ranger who put up the sign must have meant to keep tourist vehicles out. He apparently forgot that the sheep camps were coming.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

### Lamb Liver in Salsa

Oil
1½ pounds lamb liver, cut in narrow strips
Flour
1 large onion, peeled and chopped
1 clove garlic, peeled and chopped
1½ cups tomato sauce
2 tablespoons chopped fresh parsley
1 teaspoon dried oregano
Salt
Pepper
1 lemon, sliced thinly (optional)

1. Heat oil in a skillet. Meanwhile, dredge liver strips in flour. Shake off excess flour and brown in hot oil. Remove strips with a spatula as soon as they brown and drain on paper toweling.
2. Add all remaining ingredients to the drippings in the skillet, along with 2 cups waters. Bring to a boil, reduce heat, and simmer 15 minutes.
3. Return liver strips to skillet and cook at a slow simmer. Test the liver after a few minutes and remove it to a serving platter as soon as it has absorbed the sauce's flavor. Do not overcook. Use excess sauce with spaghetti served on the side or at another meal.

Yield: 4–6 servings

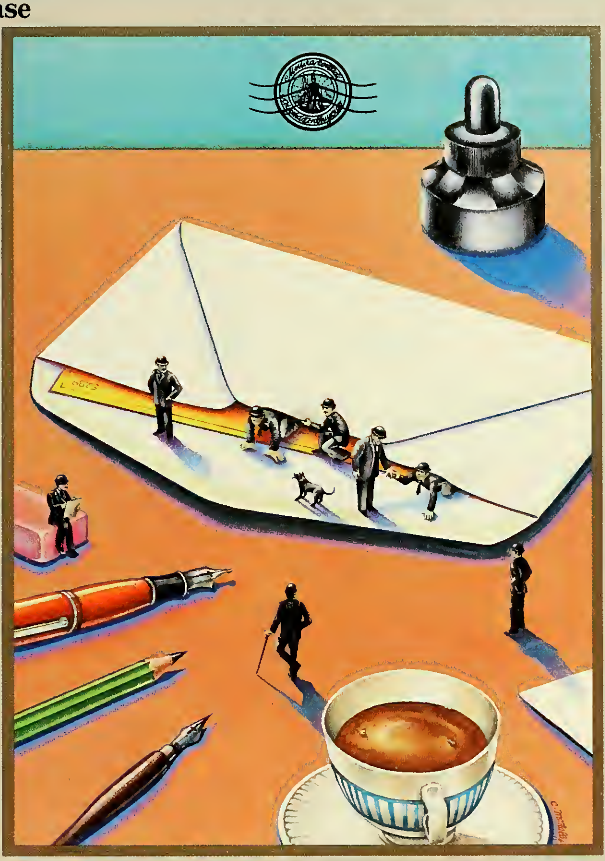
### Lamb Avgolemono

2 pounds lamb, stewing meat or shoulder, cut in chunks
2 tablespoons olive oil or butter
1 large onion, chopped
5–6 celery ribs cut in 2-inch sections
1 teaspoon salt
Pepper
3 large eggs
1 tablespoon cornstarch
Juice of 2 lemons

1. Brown meat, a few pieces at a time, in very hot oil, in a heavy pot. Reserve.
2. Reduce heat and brown onion and celery lightly in the same oil. Return browned lamb to pot, add salt, pepper, and 3 cups water. Bring to a boil, reduce heat and simmer, covered, for 1½ hours or until meat is tender.
3. To make sauce, remove 2 cups hot cooking liquid and reserve. Then, beat eggs in a bowl until frothy. Add cornstarch and beat until thoroughly incorporated. Add lemon juice gradually, beating as you add it. Pour in reserved cooking liquid in a slow stream, beating constantly.
4. Pour finished sauce over meat, which should still be hot. You can heat this gently, or keep it on the stove over low heat until ready to serve, but do not boil. The best thing is to serve it immediately.

Yield: 4–6 servings

# "Chief, there's more to this case than meets the eye!"



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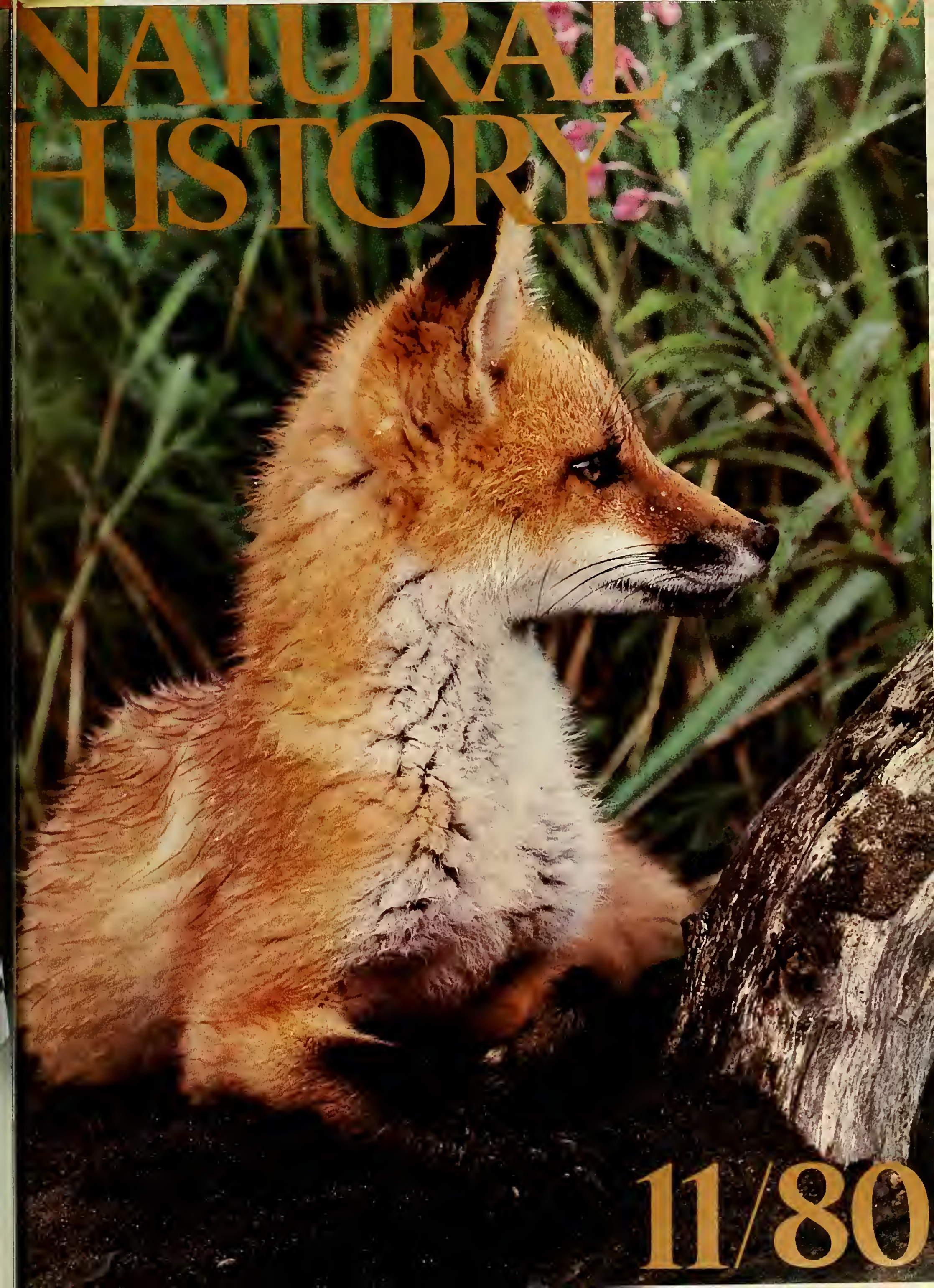

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*Vol. 89, No. 11, November 1980*

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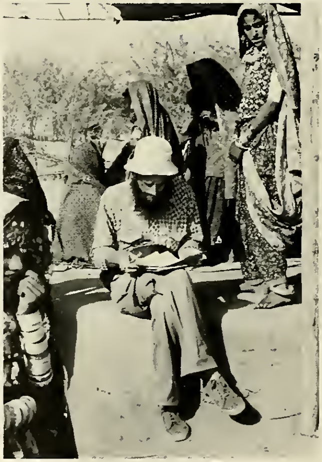
# Authors

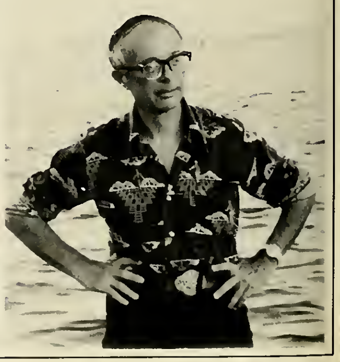
"The curiosity of our summer school students was the beginning of our interest in bogs. No feature of the Irish landscape prompted more questions," according to coauthors **Sharon Bohn Gmelch** and **George Gmelch**. The Gmelches, who both received their Ph.D.'s from the University of California at Santa Barbara in 1975, had previously done fieldwork with Irish tinkers. George Gmelch recently studied the return migration and readjustment of Irish emigrants, having carried out a similar study of indigenes in Newfoundland. The Gmelches have now turned their attention to Britain, where they are looking at the migration patterns and living needs of gypsies and tinkers. Sharon Bohn Gmelch is visiting assistant professor at Union College, Schenectady, New York, and adjunct assistant professor of anthropology at the State University of New York at Albany, where George Gmelch is assistant professor of anthropology.

**J. David Henry** became interested in the red fox the first time he saw one, in the Canadian boreal forest of northern Saskatchewan. He had gone there in 1971 to work on a black bear management program in Prince Albert National Park. Switching his attention to the foxes in the park, he found that, with much patience, he could observe them in their habitat. His observations developed into a doctoral research project on the adaptive strategies of the red fox. An environmental consultant and instructor of ecology at Saskatchewan Indian College of the University of Regina, Henry has also worked as a lumberjack. When city-bound, he watches cats hunt their prey in back alleys and vacant lots.



"I dreamed for years," explains architectural historian **Jean-Louis Bourgeois,** "of doing research as far removed as possible—in all senses—from the World Trade Center in New York." He was attracted to wind scoops and other desert structures after seeing their sculpturelike forms in pictures. With photographer Carollee Pelos, he documented rural Muslim shrines in Afghanistan, leaving the area not long before the Russian intervention. The two also explored architecture and local village life in the Great Indian Desert, and are currently off to the Sahara to gather more material for their planned book on desert architecture. Bourgeois is a graduate of Harvard University, where he studied literature and architectural history.

As a student at the University of Bologna in Italy, **Cesare Emiliani** found marine deposits dating back to the ice ages readily accessible, for Bologna long ago was a coastal city. Intrigued by the local material, Emiliani studied geology in Bologna and subsequently took an advanced degree in the subject at the University of Chicago. For almost a quarter of a century he has taught marine geology, with an emphasis on the history of the ice ages, at the University of Miami in Florida. His current research is centered on isotope paleoclimatology. Emiliani has written many papers on ancient temperatures and climates based on his work with deep-sea cores.



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# Doctor, Lawyer, Indian Chief

*As Punjabi villagers say, "You never really know who a man is until you know who his grandfather and his ancestors were"*

**by Richard Kurin**

I was full of confidence when—equipped with a scholarly proposal, blessings from my advisers, and generous research grants—I set out to study village social structure in the Punjab province of Pakistan. But after looking for an appropriate fieldwork site for several weeks without success, I began to think that my research project would never get off the ground. Daily I would seek out villages aboard my puttering motor scooter, traversing the dusty dirt roads, footpaths, and irrigation ditches that crisscross the Punjab. But I couldn't seem to find a village amenable to study. The major problem was that the villagers I did approach were baffled by my presence. They could not understand why anyone would travel ten thousand miles from home to a foreign country in order to live in a poor village, interview illiterate peasants, and then write a book about it. Life, they were sure, was to be lived, not written about. Besides, they thought, what of any importance could they possibly tell me? Committed as I was to ethnographic research, I readily understood their viewpoint. I was a *babu log*—literally, a noble; figuratively, a clerk; and simply, a person of the city. I rode a motor scooter, wore tight-fitting clothing, and spoke Urdu, a language associated with the urban literary elite. Obviously, I did not belong, and the villagers simply did not see me fitting into their society.

The Punjab, a region about the size of Colorado, straddles the northern border of India and Pakistan. Partitioned between the two countries in 1947, the Punjab now consists of a western province, inhabited by Muslims, and an eastern one, populated in the main by Sikhs and Hindus. As its name implies—*punj* meaning "five" and *ab* meaning "rivers"—the region is endowed with plentiful resources to support widespread agriculture and a large rural population. The Punjab has traditionally supplied grains, produce, and dairy products to the peoples of neighboring and considerably more arid states, earning it a reputation as the breadbasket of southern Asia.

Given this predilection for agriculture, Punjabis like to emphasize that they are earthy people, having values they see as consonant with rural life. These values include an appreciation of, and trust in, nature; simplicity and directness of expression; an awareness of the basic drives and desires that motivate men (namely, *zan*, *zar*, *zamin*—"women, wealth, land"); a concern with honor and shame as abiding principles of social organization; and for Muslims, a deep faith in Allah and the teachings of his prophet Mohammad.

Besides being known for its fertile soils, life-giving rivers, and superlative agriculturists, the Punjab is also perceived as a zone of transitional culture, a region that has experienced repeated invasions of peoples from western and central Asia into the Indian subcontinent. Over the last four thousand years, numerous groups, among them Scythians, Parthians, Huns, Greeks, Moguls, Persians, Afghans, and Turks, have entered the subcontinent through the Punjab in search of bountiful land, riches, or power. Although Punjabis—notably Rajputs, Sikhs, and Jats—have a reputation for courage and fortitude on the battlefield, their primary, self-professed strength has been their ability to incorporate new, exogenous elements into their society with a minimum of conflict. Punjabis are proud that theirs is a multiethnic society in which diverse groups have been largely unified by a common language and by common customs and traditions.

Given this background, I had not expected much difficulty in locating a village in which to settle and conduct my research. As an anthropologist, I viewed myself as an "earthy" social scientist who, being concerned with basics, would have a good deal in common with rural Punjabis. True, I might be looked on as an invader of a sort; but I was benevolent, and sensing this, villagers were sure to incorporate me into their society with even greater ease than was the case for the would-be conquering armies that had preceded me. Indeed, they would welcome me with open arms.

I was wrong. The villagers whom I approached attributed my desire to live with them either to neurotic de-

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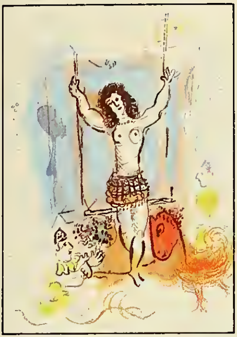
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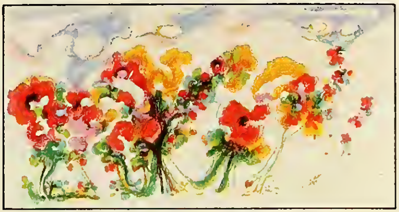
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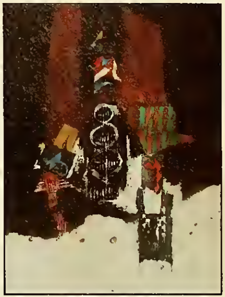
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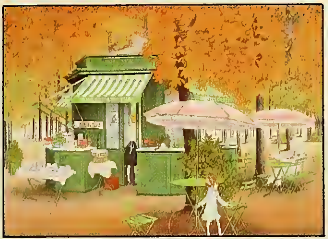
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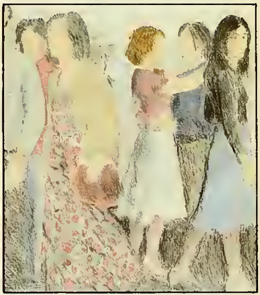
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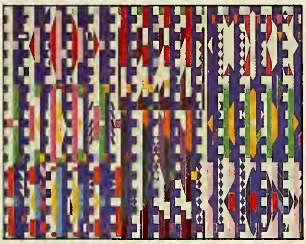
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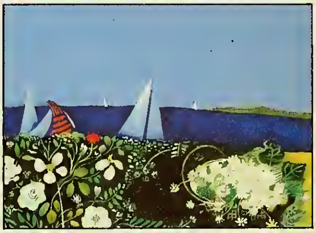
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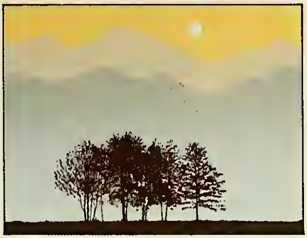
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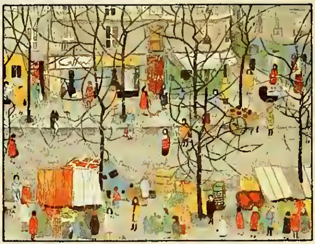
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lusions or nefarious ulterior motives. Perhaps, so the arguments went, I was really after women, land, or wealth.

On the day I had decided would be my last in search of a village, I was driving along a road when I saw a farmer running through a rice field and waving me down. I stopped and he climbed on the scooter. Figuring I had nothing to lose, I began to explain why I wanted to live in a village. To my surprise and delight, he was very receptive, and after sharing a pomegranate milkshake at a roadside shop, he invited me to his home. His name was Allah Ditta, which means "God given," and I took this as a sign that I had indeed found my village.

"My" village turned out to be a settlement of about fifteen hundred people, mostly of the Nunari *qaum*, or "tribe." The Nunaris engage primarily in agriculture (wheat, rice, sugar cane, and cotton), and most families own small plots of land. Members of the Bhatti tribe constitute the largest minority in the village. Although traditionally a warrior tribe, the Bhattis serve in the main as the village artisans and craftsmen.

On my first day in the village I tried explaining in great detail the purposes of my study to the village elders and clan leaders. Despite my efforts, most of the elders were perplexed about why I wanted to live in their village. As a guest, I was entitled to the hospitality traditionally bestowed by Muslim peoples of Asia, and during the first evening I was assigned a place to stay. But I was an enigma, for guests leave, and I wanted to remain. I was also perceived as being strange, for I was both a non-Muslim and a non-Punjabi, a type of person not heretofore encountered by most of the villagers. Although I tried to temper my behavior, there was little I could say or do to dissuade my hosts from the view that I embodied the antithesis of Punjabi values. While I was able to converse in their language, Jatki, a dialect of western Punjabi, I was only able to do so with the ability of a four-year-old. This achievement fell far short of speaking the *t'et'*, or "genuine form," of the villagers. Their idiom is rich with the terminology of agricultural operations and rural life. It is unpretentious, uninflected, and direct, and villagers hold high opinions of those who are good with words, who can speak to a point and be convincing. Needless to say, my infantile babble realized

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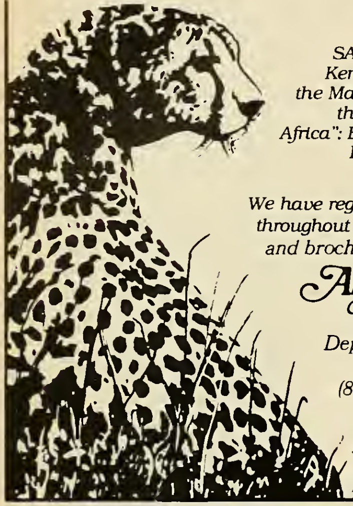

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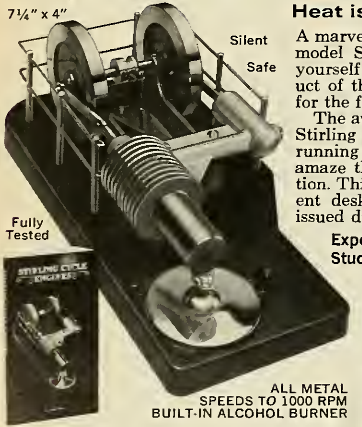

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none of these characteristics and evoked no such respect.

Similarly, even though I wore indigenous dress, I was inept at tying my *lungi*, or pant cloth. The fact that my *lungi* occasionally fell off and revealed what was underneath gave my neighbors reason to believe that I indeed had no shame and could not control the passions of my *nafs*, or "libidinous nature."

This image of a doltish, shameless infidel barely capable of caring for himself lasted for the first week of my residence in the village. My inability to distinguish among the five varieties of rice and four varieties of lentil grown in the village illustrated that I knew or cared little about nature and agricultural enterprise. This display of ignorance only served to confirm the general consensus that the mysterious morsels I ate from tin cans labeled "Chef Boy-ar-Dee" were not really food at all. Additionally, I did not oil and henna my hair, shave my armpits, or perform ablutions, thereby convincing some commentators that I was a member of a species of subhuman beings, possessing little in the form of either common or moral sense. That the villagers did not quite grant me the status of a person was reflected by their not according me a proper name. In the Punjab, a person's name is equated with honor and respect and is symbolized by his turban. A man who does not have a name, or whose name is not recognized by his neighbors, is unworthy of respect. For such a man, his turban is said to be either nonexistent or to lie in the dust at the feet of others. To be given a name is to have one's head crowned by a turban, an acknowledgment that one leads a responsible and respectable life. Although I repeatedly introduced myself as "Rashid Karim," a fairly decent Pakistani rendering of Richard Kurin, just about all the villagers insisted on calling me *Angrez* ("Englishman"), thus denying me full personhood and implicitly refusing to grant me the right to wear a turban.

As I began to pick up the vernacular, to question villagers about their clan and kinship structure and trace out relationships between different families, my image began to change. My drawings of kinship diagrams and preliminary census mappings were looked upon not only with wonder but also suspicion. My neighbors now began to think there might be a method to my madness. And so there was.

Now I had become a spy. Of course it took a week for people to figure out whom I was supposedly spying for. Located as they were at a crossroads of Asia, at a nexus of conflicting geopolitical interests, they had many possibilities to consider. There was a good deal of disagreement on the issue, with the vast majority maintaining that I was either an American, Russian, or Indian spy. A small, but nonetheless vocal, minority held steadfastly to the belief that I was a Chinese spy. I thought it all rather humorous until one day a group confronted me in the main square in front of the nine-by-nine-foot mud hut that I had rented. The leader spoke up and accused me of spying. The remainder of the group grumbled *jahsus! jahsus!* ("spy! spy!"), and I realized that this ad hoc committee of inquiry had the potential of becoming a mob.

To be sure, the villagers had good reason to be suspicious. For one, the times were tense in Pakistan—a national political crisis gripped the country and the populace had been anxious for months over the uncertainty of elections and effective governmental functions. Second, keenly aware of their history, some of the villagers did not have to go too far to imagine that I was at the vanguard of some invading group that had designs upon their land. Such intrigues, with far greater sophistication, had been played out before by nations seeking to expand their power into the Punjab. That I possessed a gold seal letter (which no one save myself could read) from the University of Chicago to the effect that I was pursuing legitimate studies was not enough to convince the crowd that I was indeed an innocent scholar.

I repeatedly denied the charge, but to no avail. The shouts of *jahsus! jahsus!* prevailed. Confronted with this I had no choice.

"Okay," I said. "I admit it. I am a spy!"

The crowd quieted for my long-awaited confession.

"I am a spy and am here to study this village, so that when my country attacks you we will be prepared. You see, we will not bomb Lahore or Karachi or Islamabad. Why should we waste our bombs on millions of people, on factories, dams, airports, and harbors? No, it is far more advantageous to bomb this strategic small village replete with its mud huts, livestock, Persian wheels, and one light bulb. And when we bomb this village, it

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is imperative that we know how Allah Ditta is related to Abdullah, and who owns the land near the well, and what your marriage customs are.”

Silence hung over the crowd, and then one by one the assemblage began to disperse. My sarcasm had worked. The spy charges were defused. But I was no hero in light of my performance, and so I was once again relegated to the status of a nonperson without an identity in the village.

I remained in limbo for the next week, and although I continued my attempts to collect information about village life, I had my doubts as to whether I would ever be accepted by the villagers. And then, through no effort of my own, there was a breakthrough, this time due to another Allah Ditta, a relative of the village headman and one of my leading accusers during my spying days.

I was sitting on my woven string bed on my porch when Allah Ditta approached, leading his son by the neck. “Oh, *Angrez*!” he yelled, “this worthless son of mine is doing poorly in school. He is supposed to be learning English, but he is failing. He has a good mind, but he’s lazy. And his teacher is no help, being more intent upon drinking tea and singing film songs than upon teaching English. Oh son of an Englishman, do you know English?”

“Yes, I know English,” I replied, “after all, I am an *Angrez*.”

“Teach him,” Allah Ditta blurted out, without any sense of making a tactful request.

And so, I spent the next hour with the boy, reviewing his lessons and correcting his pronunciation and grammar. As I did so, villagers stopped to watch and listen, and by the end of the hour, nearly one hundred people had gathered around, engrossed by this tutoring session. They were stupefied. I was an effective teacher, and I actually seemed to know English. The boy responded well, and the crowd reached a new consensus. I had a brain. And in recognition of this achievement I was given a name—“Ustad Rashid,” or Richard the Teacher.

Achieving the status of a teacher was only the beginning of my success. The next morning I awoke to find the village sugar vendor at my door. He had a headache and wanted to know if I could cure him.

“Why do you think I can help you?” I asked.

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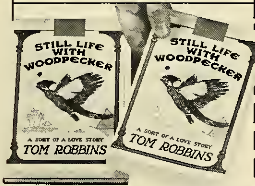

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Bhai Khan answered, "Because you are a *ustad*, you have a great deal of knowledge."

The logic was certainly compelling. If I could teach English, I should be able to cure a headache. I gave him two aspirins.

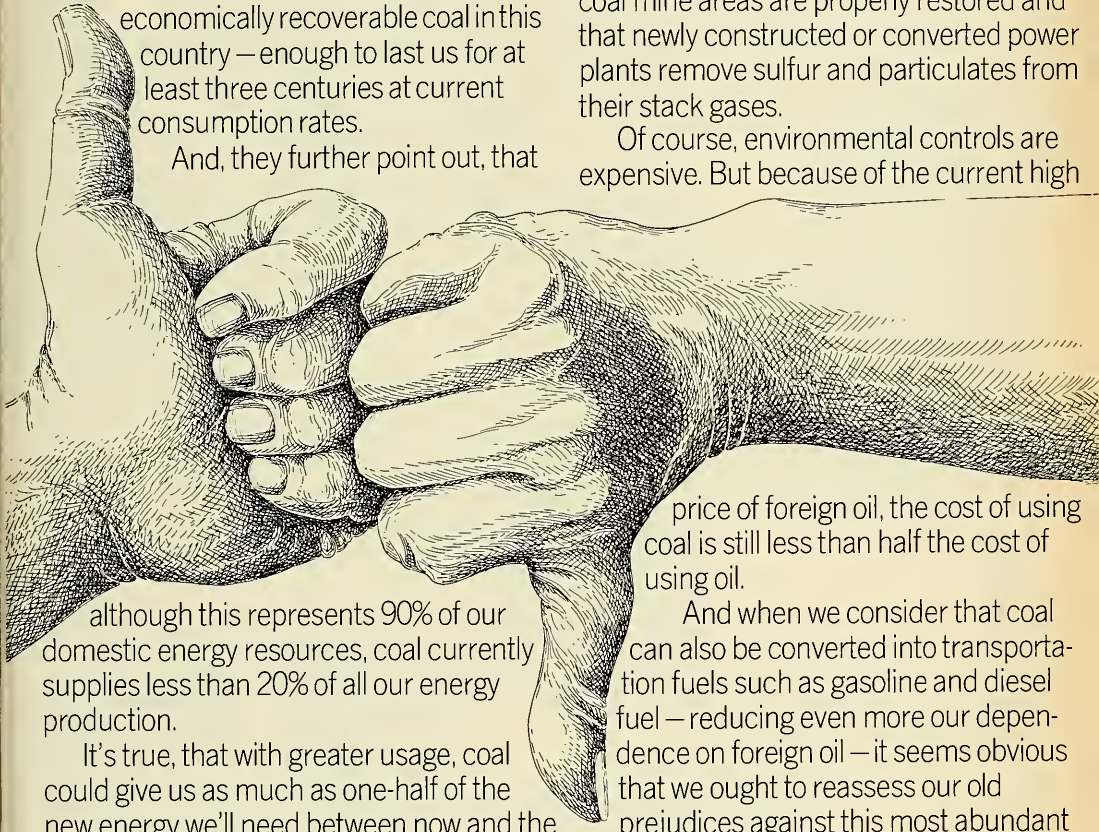
An hour later, my fame had spread. Bhai Khan had been cured, and he did not hesitate to let others know that it was the *ustad* who had been responsible. By the next day, and in fact for the remainder of my stay, I was to see an average of twenty-five to thirty patients a day. I was asked to cure everything from coughs and colds to typhoid, elephantiasis, and impotency. Upon establishing a flourishing and free medical practice, I received another title, *hakim*, or "physician." I was not yet an anthropologist, but I was on my way.

A few days later I took on yet another role. One of my research interests involved tracing out patterns of land ownership and inheritance. While working on the problem of figuring out who owned what, I was approached by the village watchman. He claimed he had been swindled in a land deal and requested my help. As the accused was not another villager, I agreed to present the watchman's case to the local authorities.

Somehow, my efforts managed to achieve results. The plaintiff's grievance was redressed, and I was given yet another title in the village—*wakil*, or "lawyer." And in the weeks that followed, I was steadily called upon to read, translate, and advise upon various court orders that affected the lives of the villagers.

My roles as teacher, doctor, and lawyer not only provided me with an identity but also facilitated my integration into the economic structure of the community. As my imputed skills offered my neighbors services not readily available in the village, I was drawn into exchange relationships known as *seipi*. *Seipi* refers to the barter system of goods and services among village farmers, craftsmen, artisans, and other specialists. Every morning Roshan the milkman would deliver fresh milk to my hut. Every other day Hajam Ali the barber would stop by and give me a shave. My next-door neighbor, Nura the cobbler, would repair my sandals when required. Ghulam the horse-cart driver would transport me to town when my motor scooter was in disrepair. The parents of my students would send

# Some insist coal is good. Some insist coal is bad.
# We insist it's not that black or white.



Those who insist that coal is good point out that we have over 200 billion tons of economically recoverable coal in this country—enough to last us for at least three centuries at current consumption rates.

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But those who insist that coal is bad point to abandoned mines which scar the landscape and allow acid water to seep into streams.

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And when we consider that coal can also be converted into transportation fuels such as gasoline and diesel fuel—reducing even more our dependence on foreign oil—it seems obvious that we ought to reassess our old prejudices against this most abundant of all fossil fuels.

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me sweets and sometimes delicious meals. In return, none of my neighbors asked for direct payment for the specific actions performed. Rather, as they told me, they would call upon me when they had need of my services. And they did. Nura needed cough syrup for his children, the milkman's brother needed a job contact in the city, students wanted to continue their lessons, and so on. Through *seipi* relations, various neighbors gave goods and services to me, and I to them.

Even so, I knew that by Punjabi standards I could never be truly accepted into village life because I was not a member of either the Nunari or Bhatti tribe. As the villagers would say, "You never really know who a man is until you know who his grandfather and his ancestors were." And to know a person's grandfather or ancestors properly, you had to be a member of the same or a closely allied tribe.

The Nunari tribe is composed of a number of groups. The nucleus consists of four clans—Naul, Vadel, Saddan, and More—each named for one of four brothers thought to have originally founded the tribe. Clan members are said to be related by blood ties, also called *pag da sak*, or "ties of the turban." In sharing the turban, members of each clan share the same blood, the same honor, and the same name. Other clans, unrelated by ties of blood to these four, have become attached to this nucleus through a history of marital relations or of continuous political and economic interdependence. Marital relations, called *gag da sak*, or "ties of the skirt," are conceived of as relations in which alienable turbans (skirts) in the form of women are exchanged with other, non-turban-sharing groups. Similarly, ties of political and economic domination and subordination are thought of as relations in which the turban of the client is given to that of the patron. A major part of my research work was concerned with reconstructing how the four brothers formed the Nunari tribe, how additional clans became associated with it, and how clan and tribal identity were defined by nomenclature, codes of honor, and the symbols of sharing and exchanging turbans.

To approach these issues I set out to reconstruct the genealogical relationships within the tribe and between the various clans. I elicited genealogies from many of the villagers and

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questioned older informants about the history of the Nunari tribe. Most knew only bits and pieces of this history, and after several months of interviews and research, I was directed to the tribal genealogists. These people, usually not Nunaris themselves, perform the service of memorizing and then orally relating the history of the tribe and the relationships among its members. The genealogist in the village was an aged and arthritic man named Hedayat, who in his later years was engaged in teaching the Nunari genealogy to his son, who would then carry out the traditional and hereditary duties of his position.

The villagers claimed that Hedayat knew every generation of the Nunari from the present to the founding brothers and even beyond. So I invited Hedayat to my hut and explained my purpose.

"Do you know Allah Ditta son of Rohm?" I asked.

"Yes, of course," he replied.

"Who was Rohm's father?" I continued.

"Shahadat Mohammad," he answered.

"And his father?"

"Hamid."

"And his?"

"Chigatah," he snapped without hesitation.

I was now quite excited, for no one else in the village had been able to recall an ancestor of this generation. My estimate was that Chigatah had been born sometime between 1850 and 1870. But Hedayat went on.

"Chigatah's father was Kamal. And Kamal's father was Nanak. And Nanak's father was Sikhu. And before him was Dargai, and before him Maiy. And before him was Siddiq. And Siddiq's father was Nur. And Nur's Asmat. And Asmat was of Channa. And Channa of Nau. And Nau of Bhatta. And Bhatta was the son of Koduk."

Hedayat had now recounted sixteen generations of lineal ascendants related through the turban. Koduk was probably born in the sixteenth century. But still Hedayat continued.

"Sigun was the father of Koduk. And Man the father of Sigun. And before Man was his father Maneswar. And Maneswar's father was the founder of the clan, Naul."

This then was a line of the Naul clan of the Nunari tribe, ascending twenty-one generations from the present descendants (Allah Ditta's sons) to the founder, one of four brothers who lived perhaps in the fifteenth century. I asked Hedayat to recite genealogies of the other Nunari clans, and he did, with some blanks here and there, ending with Vadel, More, and Saddan, the other three brothers who formed the tribal nucleus. I then asked the obvious question, "Hedayat, who was the father of these four brothers? Who is the founding ancestor of the Nunari tribe?"

"The father of these brothers was not a Muslim. He was an Indian rajput [chief]. The tribe actually begins with the conversion of the four brothers," Hedayat explained.

"Well then," I replied, "who was this Indian chief?"

He was a famous and noble chief who fought against the Moguls. His name was Raja Kurin, who lived in a massive fort in Kurinnagar, about twenty-seven miles from Delhi."

"What!" I asked, both startled and unsure of what I had heard.

"Raja Kurin is the father of the brothers who make up—"

"But his name! It's the same as mine," I stammered. "Hedayat, my name is Richard Kurin. What a coincidence! Here I am living with your tribe thousands of miles from my home and it turns out that I have the same name as the founder of the tribe! Do you think I might be related to Raja Kurin and the Nunaris?"

Hedayat looked at me, but only for an instant. Redoing his turban, he tilted his head skyward, smiled, and asked, "What is the name of your father?"

I had come a long way. I now had a name that could be recognized and respected, and as I answered Hedayat, I knew that I had finally and irrevocably fit into "my" village. Whether by fortuitous circumstance or by careful manipulation, my neighbors had found a way to take an invading city person intent on studying their life and transform him into one of their own, a full person entitled to wear a turban for participating in, and being identified with, that life. As has gone on for centuries in the region, once again the new and exogenous had been recast into something Punjabi.

**Epilogue:** There is no positive evidence linking the Nunaris to a historical Raja Kurin, although there are several famous personages identified by that name (also transcribed as Karan and Kurran). Estimated from the genealogy recited by Hedayat, the founding of the tribe by the four brothers appears to have occurred sometime between 440 and 640 years ago, depending on the interval assumed for each generation. On that basis, the most likely candidate for Nunari progenitor (actual or imputed) is Raja Karan, ruler of Anhilvara (Gujerat), who was defeated by the Khilji Ala-ud-Din in 1297 and again in 1307. Although this is slightly earlier than suggested by the genealogical data, such genealogies are often telescoped or otherwise unreliable.

Nevertheless, several aspects of Hedayat's account make this association doubtful. First, Hedayat clearly identifies Raja Kurin's conquerors as Moguls, whereas the Gujerati Raja Karan was defeated by the Khiljis. Second, Hedayat places the Nunari ancestor's kingdom only twenty-seven miles from Delhi. The Gujerati Raja Karan ruled several kingdoms, none closer than several hundred miles to Delhi.

Other circumstances, however, offer support for this identification of the Nunari ancestor. According to Hedayat, Raja Kurin's father was named Kam Deo. Although the historical figure was the son of Serung Deo, the use of "Deo," a popular title for the rajas of the Vaghela and Solonki dynasties, does seem to place the Nunari founder in the context of medieval Gujerat. Furthermore, Hedayat clearly identifies the saint (*pir*) said to have initiated the conversion of the Nunaris to Islam. This saint, Mukhdum-i-Jehaniyan, was a contemporary of the historical Raja Karan.

Also of interest, but as yet unexplained, is that several other groups living in Nunari settlement areas specifically claim to be descended from Raja Karan of Gujerat, who is said to have migrated northward into the Punjab after his defeat. Controverting this theory, the available evidence indicates that Raja Karan fled, not toward the Punjab, but rather southward to the Deccan, and that his patriline ended with him. It is his daughter Deval Devi who is remembered: she is the celebrated heroine of "Ashiqa," a famous Urdu poem written by Amir Khusrau in 1316. She was married to Khizr Khan, the son of Karan's conqueror; nothing is known of her progeny.

*Richard Kurin teaches community development at Southern Illinois University at Carbondale.*

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# Oh Sex, Where Is Thy Sting?

*Insect romance can be a deadly serious affair*

**by Milton Love**

You might expect male insects or spiders to view life as just one salacious experience after another. After all, many are sort of simpletons, ready to mate anytime, anywhere, seemingly with anything. (Your mother was right, you know, they are After Only One Thing.) If, in his exuberance, a male mates at the wrong time—for example, with a female carrying immature eggs—he usually loses little. Sperm is cheap to produce, and its loss will not significantly hinder future reproductive possibilities.

However, pitfalls and traumas line the primrose path of lust for our intrepid Lotharios.

A female must be careful about when and with whom she copulates. For instance, if her eggs are already fertilized, further mating serves no purpose, and her time is better spent in feeding, avoiding predators, and so forth. Moreover, since they expend a great deal of energy in producing eggs and perhaps caring for young, females must exercise some discretion in choosing mates.

Thus, an overeager male faced with a more reticent, pragmatic female may find sex to be a tension-filled, and possibly terminal, experience.

Female rejection of male advances is rarely subtle. After her eggs are fertilized, the female ground beetle, *Pterostichus lucublandus*, will not mate again. An unreceptive female runs away when a male attempts to mate with her. If the male continues his advances, the female discharges a liquid from the tip of her abdomen. The male immediately stops and tries to wipe the substance off his feet and antennae, but within ten seconds, like a Keystone Cop falling off a motorcycle, the beetle keels over in a coma. He remains comatose for one to three hours, thereby allowing the female enough time to leave the area and safely deposit her eggs (which the male might otherwise eat).

If a female does not choose to mate, she may so indicate by attacking and sometimes killing the male, a behavior particularly common in spiders. Hence, male spiders are usually quite tentative in early courtship behavior. Many will first pluck at the webs of females to see how they respond. A fast-charging female is not a positive sign. In purse-web spiders, females live in silken tubes. The male seeks out a female tube and taps rapidly with palps and legs. If the female is not receptive, she will violently tug back. Lack of movement signals receptivity, and the male tears open the tube and enters.

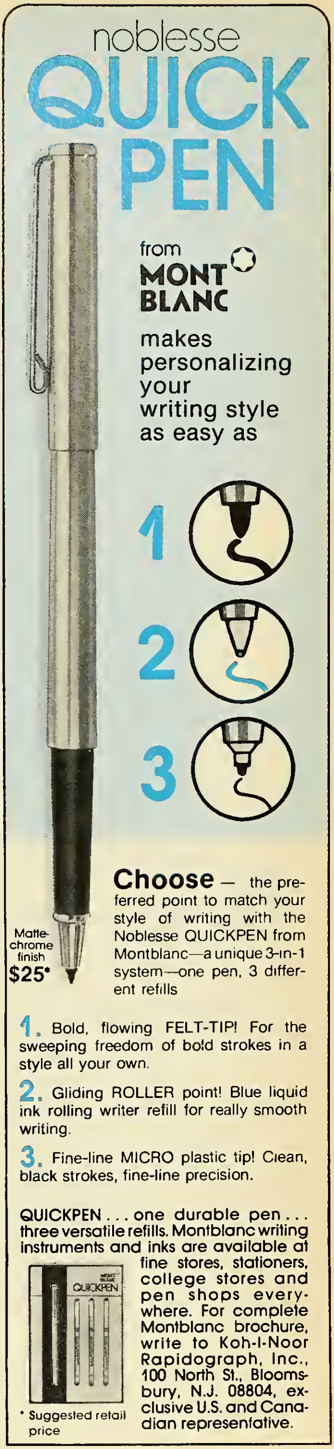
Male spiders have a particular problem, as the transfer of sperm involves taking sperm packets and inserting them into receptacles on the underside of the female. This necessitates coming close to her jaws and, unless the female is willing or incapacitated, this is hazardous duty indeed.

Predictably, a number of behavioral patterns have evolved to deal with this problem. Male jumping spiders, *Euophrys frontalis*, seem to mesmerize their would-be mates. When he sights a female, the male snaps his front legs up and down and vibrates his white-fringed front palps, all the while slowly advancing. Females become quiescent through this behavior, and mating occurs soon after. The male crab spider, *Xysticus cristalus*, succeeds by seizing his mate by her front legs, wrestling her to the ground, and wrapping her in silk. He then crawls under her and deposits the sperm. *Pisaura mirabilis*, a wolf spider, is more subtle. He offers the female a wrapped fly, holding it aloft. As she advances, he leans farther and farther backward, so that eventually she is raised upward adjacent to him. As she grabs and eats the present, he slides underneath her.

The evolution of male self-preservation is brought to an aesthetically delightful turn among balloon flies (family Empididae). In the most primitive species, males are occasionally captured and eaten by females during early courtship. In somewhat more advanced species, the male captures an insect, seeks out a potential mate, and presents it to her. While the distracted female feeds on the gift, the male mates in relative safety.

A further refinement has evolved in some species. Although males capture prey, they do not actively seek out females. Rather, a large number of males swarm together, and females make the selection. The prey now seems to serve as an attractant for females.

More complicated behavior is seen in those species where the males attach threads or sticky patches to the gift prey. Originally, these helped to capture and subdue the struggling insect. In their more advanced stage, however, the wrappings have taken on a meaning all their own. Here the prey is no longer the prime female attractant and the male probably eats the prey himself. As we look at this species sequence, the prey becomes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smaller and smaller; in some species only a tiny, inedible fly is attached to the "balloon," and neither sex eats it. Now the gossamer, ornate balloon is what attracts the females. In its last stages, there is no prey at all involved in courtship, and the male presents the female with only an iridescent balloon as a token of his affection.

Some males do not have a defense against female predation, and in this respect, sex between praying mantids is unique. Upon recognizing a female, the male first stops, then slowly approaches. When sufficiently close, he jumps on her back and attempts to mate. Usually, the female reaches back and begins eating the male's head. Intriguingly, what we might consider antisocial behavior does not signal an end to copulation. Rather, the nervous system of the male mantid is such that head removal triggers off forceful copulating movements. Even if an approaching male is captured by a female and his head removed before he reaches her back, he will walk about in a circular path, eventually stopping next to her body. The headless individual then climbs up onto the female's back and mating commences. Although I personally would shrink from such heroics, we must surely acknowledge this manifestation of sheer determination.

Male insects face other problems unrelated to female behavior. For instance, male fireflies of the genus *Photinus* search at night for females, which flash a species-specific pattern. Unfortunately for these nocturnal males, female fireflies of the genus *Photuris* have evolved to mimic signals of female *Photinus*. When the male flies within reach of his putative mate, the impostor reaches out, grabs, and devours him.

*Gryllus integer*, a field cricket, has other difficulties. Males spend warm nights rubbing forewings together trying to attract females. However, the tachinid fly *Euphasiopteryx ochracea* is also attracted to the calling males. If a female fly finds the cricket, she will plant larvae on it. The larvae burrow into the cricket's body, and it dies soon after. Some male *Gryllus* seem to reduce their chances of parasitism while still enjoying the opportunity to mate. These are noncalling males that wait in ambush near a calling male and attempt to copulate with an arriving female before the crooner has an opportunity. In one species of katydids, calling males try to outwit noncallers by lowering the intensity of their call once the answering click of a female is heard, thus reducing the possibility of a noncaller locating the mating site.

Earlier, we discussed the prey-proffering balloon flies. Merely giving a prey gift, however, may not be enough to insure mating in some insects, for instance the scorpion-fly, *Bittachus apicalis*.

A comedy of errors begins with a male capturing a prey arthropod. After tasting it to ascertain its palatability, the male releases a female-attracting pheromone. When the attracted female comes near, she lowers her wings, a signal to the male to present the gift. If the gift is acceptable, mating occurs. (Ever the romantic, a male will usually try to regain the prey to use again after mating.)

However, capturing prey items is time and energy consuming, and hunters run the risk of being captured by predators such as spiders. Using behavior reminiscent of the play *Charley's Aunt*, many or perhaps most males will try to wrest away an already captured prey from other males by the insect version of transvestism. Males bent on pirating will approach gift-bearing males and lower their wings in a manner possibly identical to that of females. One study showed that in 67 percent of these deceptions, the gift-bearing male did indeed proffer the gift to the transvestite. After about two minutes the duped male realizes something is amiss and tries to regain the prize. The transvestite successfully retains the prey about 33 percent of the time. One assumes the gulled male then stalks off for a long, cold shower.

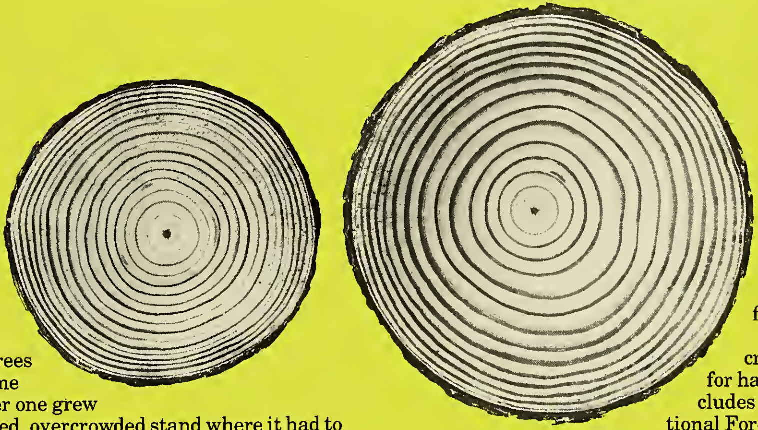
Perhaps the unkindest cut of all befalls the male of the damselfly species *Calopteryx maculata*. Females of this species store sperm and may mate more than once. To protect their parental investment, males guard females against attempted takeovers. If a male successfully takes a female away, he removes the sperm already stored, using a hair-lined, horn part of the penis. After removing most or all of his rival's sperm, he transfers his own.

Needless to say, damselfly paternity suits are beastly affairs.

*Milton Love is a research associate in the Department of Biology at Occidental College, Los Angeles.*

A report on the great American forest.

# Look what happens when Mother Nature gets a little help.



These log slices dramatically show the value of modern, scientific forest management. Both (shown 36% of actual size) are from trees of about the same age. The smaller one grew in an unmanaged, overcrowded stand where it had to compete for sunlight and moisture. The other is from a grove that was thinned to give the best trees room to thrive.

This is just one of many ways forest management can help meet a predicted doubling of domestic demand for wood and paper products in the next 50 years.

The forest industry has learned how to help Mother Nature grow more trees, faster, by applying scientific forest management techniques: encouraging natural regrowth, planting superior seeds and seedlings, fertilizing, protecting against disease and insects, thinning, watching carefully until time to harvest — then starting the cycle again.

## Demand keeps rising.

Forest management like this is vital because every year Americans need more homes, more paper products, more packaging and containers, more fuelwood, more of the thousands of other essential products that only the forest can provide.

So far, the country's commercial forest has been able to keep up with demand. (*Commercial forest,* as defined by the U.S. Forest Service, is *all* forestland—whether owned by individuals, government or the industry—that is capable of, and potentially available for, growing repeated crops of trees for harvest. It includes land in National Forests but not in National Parks or Wilderness areas.)

But trees aren't grown equally fast by all commercial forest owners. Though industry has made striking advances on its lands, productivity is lower on privately owned lands and seriously lagging in National Forests.

## Productivity not up to potential.

Overall, the U.S. Forest Service estimates average productivity of all commercial forestland is only 61 percent of potential. And at the same time, actual acreage in commercial forests keeps shrinking, as land is withdrawn for homes, highways and other needs of an expanding population.

So we as a nation still have a long way to go if our wood and paper products are not to become scarce and expensive.

If you'd like to be better informed on how important it is to keep America's forests productive, write American Forest Institute, P.O. Box 873, Springfield, VA 22150 for a free booklet, "The Great American Forest."

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# Terrible Questions Provoke Great Responses

*A preliminary report on the responses to* Natural History*'s questionnaire, "You and the Ecology Movement"*

**by Luther P. Gerlach and Betty Radcliffe**

"This is a terrible questionnaire," protested one respondent to our 1980 "You and the Ecology Movement" questionnaire, "but the issues are so important that I had to answer." And along with the almost 4,000 others who have thus far responded, she did, indeed, give us her answers and was also part of the 32 percent who added comments in the space provided on the form. Many sent in news clippings or articles to help make their points. Some criticized the questionnaire for reflecting a bias they presumed to be *Natural History*'s, while others praised it as one more example of the good work the magazine is doing, for example, in raising environmental awareness. *Natural History* invited the authors to prepare the questionnaire and the follow-up reports. As authors, we claim complete responsibility. Luther Gerlach, the senior author, professor of anthropology at the University of Minnesota, collaborated with his research assistants in preparing the questionnaire—with Virginia Hine on the 1970 version and with Betty Radcliffe on the current one.

We have just finished coding the responses, and they are now being keypunched in preparation for computer analysis. To insure a timely final report, we will not be processing any further returns. We appreciate the cooperation of all who took the time to respond, especially those who listed the organizations that they support and those who added their comments. These will help us greatly in improving the questionnaire should it ever be republished or widely distributed again.

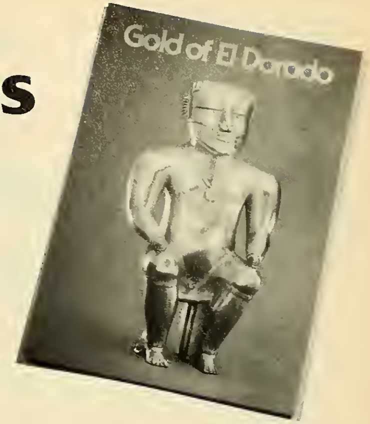
A common complaint of respondents was that even though we asked some good questions and really grabbed them with the issues, we did not provide enough choices for their answers. Many disliked having to select the best single response from three to seven options, for example, in question 17, which asked, "Which of the following seems to you the most desirable approach to achievement of a better, more adaptive energy and environmental future?" They pointed out that in resource and ecology issues—which are, indeed, survival issues—the situation is often not black or white but rather, many shades of gray, and they preferred to indicate this shading rather than take a polar position. Some felt that the options we gave them ranged nicely along the complexity of the issues, but asked why we didn't allow them to rank these options in order of importance. Others indicated that the proper answer to the resource and ecology problems we described was somehow way off our drawing board, deeply rooted somewhere else—that it lay, for example, in overpopulation, in the nature of our capitalistic system, in the way we have put a stranglehold on our capitalistic system, or in the growth of radical action on the left, action that some believed the questionnaire somehow encouraged.

What at first count seems to be a surprisingly large number of people felt that the ecology movement itself was one of our problems, along with a general drift to the left and away from the market economy. To one of the many who found great fault with the action of environmentalists, the only hope lay in the way "these antis" will be reduced in number as they drive their small and "unsafe" foreign cars. Is this just a bit of tongue in cheek? We begin to suspect, from the way these points are made time and again and from the additional news clippings sent, that there is a kind of rage here, a rage against environmentalists and those who block energy and economic development. On the other hand, others express a kind of despair that our way of life is destroying our environment and our wildlife. While a number of respondents criticized ecological organizations and a number stoutly defended their choice of personal efforts not linked to organizational membership or support, nearly two-thirds listed organizations in which they were active, some as many as thirty! It appears that, as individuals or through groups, *Natural History* readers are active in environmental concerns.

Many of the objections to our questionnaire are ones we ourselves would hold as anthropologists. Questionnaires are, after all, narrow instruments designed to produce large numbers of relatively easily analyzable responses to specific and narrowly defined questions with a limited range of answers from which to choose. Unlike some of our respondents, we do not view questionnaires as "quizzes" with right or wrong answers, as vehicles for educating people about a particular issue, or as instruments for self-analysis. Also, we are not interested in identifying respondents; we separated envelopes that would identify them and blacked out addresses stamped on the form itself. A significant advantage in the use of a questionnaire is protection of anonymity.

The main research tools of anthropologists are not questionnaires but in-depth interviews and observations in the field or "real life" situations. This gives us the shades of gray and the great variety of responses that so many respondents called for. During an interview, people can elaborate in detail, and in the process, they help us rework and expand our questions. On many of the responses to the questionnaire, we sensed the desire of people to be part of an interactive process; to get feedback from their feedback. During field research, observation of actual events enriches our understanding of the context of peoples' actions

# An Art Book That Took Centuries To Create



It took the American Museum of Natural History four years to arrange its exceptional exhibition of more than 500 pieces of ancient gold from Colombia. But those few years are a brief time when compared with the decades archeologists have spent digging (literally!) and studying the gold artifacts from tombs, caves, and buried sites. And all that time is short when compared with the many centuries prehistoric Indians practiced their craftsmanship and artistry to create these treasures.

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The second challenge for the American Museum was the creation of an appropriate book to accompany the exhibition. We decided against a traditional catalog; against a small, boring volume with tiny black-and-white pictures that could never do justice to these fine objects. Instead, we decided to present a select number of the finest pieces of pre-Columbian gold in a large, stunning format. And to represent the three important elements that make a great art book we chose outstanding professionals.

First, photographer Lee Boltin. One of the greatest photographers of art objects, he also took the famous pictures of the Tutankhamun show. We sent him abroad to find and record great pieces of pre-Columbian art.

Second, archeologist Warwick Bray, from the University of London. One of the world's foremost authorities on pre-Columbian art, Bray is also a skilled writer, able to present fascinating background in a succinct, readable essay in the book. Dr. Bray organized the Colombian gold exhibition in London.

Third, Harry N. Abrams, Inc., America's leading publisher of fine art books. In a co-publishing venture with the American Museum, Abrams designed the book, supervised the preparation of 30 large color plates, and monitored the fine-quality printing.

The result is an unprecedented exhibition book. It is bold and big—each plate is 16 by 11½ inches—bigger than this magazine *opened up*. The paper is heavier than most posters. In fact, many persons have purchased two copies of the book in order to have one set of these fine art prints for framing.

And now for the happy ending. Because the Museum is a co-publisher, we are able to offer this soft-bound art book at a major savings from its normal retail price of $12.50. We are pleased to offer *Gold of El Dorado* to subscribers for only $6.25—a 50% savings off its regular price. This special offer is valid only during the exhibition and only while our limited supply lasts. We suggest that you order one or more copies immediately. Of course, if you are not satisfied after you have had an opportunity to examine it in your home, simply return the book and the Museum will refund the purchase price.

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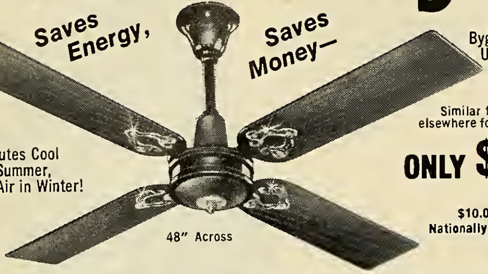

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and ideas. We certainly miss this when we work with questionnaires—both in designing them and in analyzing the results—and often feel as frustrated as some of our respondents. We recognize, however, that questionnaires are a useful instrument, and the willingness of the many respondents to fill them in showed that they feel the same way.

The 1970 questionnaire was based on field research on the ecology movement, and the rather substantial modification in 1980 was based on research on energy-conflict cases. While it narrowed the range of possible responses, the questionnaire did provoke many comments in the space we provided to elicit such open-ended additions. We could not possibly have conducted personal interviews with so many across so broad an area in so short a time.

One of the most controversial questions was number 17, in which we tried to evaluate the degree to which respondents held positions on what we considered to be an important national debate: the scale of energy technology and development and the level at which decision making about it should occur. Apparently it is not such a big debate after all. Some respondents were troubled with the way we lumped technologies instead of allowing them to choose a specific technology. Perhaps this is why many wondered, quite rightly, why we did not refer to nuclear technology, either fission or fusion, as an energy option. We do regret inadvertently omitting the word "nuclear" in choice 3 of question 17. Nuclear energy advocates were especially unhappy; fifty-eight wrote to point out this omission.

The absence of an opportunity in question 19 to choose overpopulation as the most critical ecological problem was perhaps the next most controversial item. Thirty people made a major point of this.

At least a fifth of the respondents commented in some detail on what they are doing to show their environmental concern. The majority fell into three groups, which we decided to code. People told how they were conserving energy and other resources, how they were working to preserve the environment and protect wild animals, and how they have made food-use changes, either "eating lower on the food chain" or growing more of their own food. Most of the actions reported are basic and rather ordinary,

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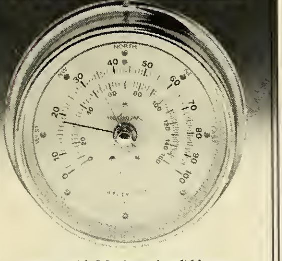

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but their sum total could be important. If, for example, this questionnaire response reflects the number of people who are stretching the life of their older cars, it is no wonder the auto industry is in trouble! Perhaps most interesting, they reported not only how they are making do with less, but also how they are becoming increasingly satisfied with this more frugal life style.

We look forward to seeing the computer results of this questionnaire: to see how they differ from 1970, to see with what attitudes about ecology the respondents begin the 1980s, and to analyze what this may portend. Our report on this will appear in a forthcoming issue. In the meantime, we wish to share with you a sampling of the interesting and provocative comments we received.

### *The Questionnaire*

Thank you for the opportunity, but it's painful to mutilate any issue of *Natural History*. Why could this not have been an insert or a blank page?

The theme of your questionnaire is to link a radical political philosophy with conservation—an unfortunate union and uncalled for.

As with most questionnaires, there is much that falls "between the two stools."

I really enjoy your magazine and am returning your questionnaire, but I do feel that the choices and wording of the questions and the narrow answers inhibit the expression of the true feelings of those of us who must work and live in the real world.

I am under the impression ambivalence or dichotomy in thought seems to catch up with you at times! Good luck!

Very poor exercise. Obviously prepared by social scientists or technically uninformed since questions 15–19 all miss the most important points and thereby force bias toward improper conclusions.

I feel many of your listed answers (like 14–25) . . . are technologically oriented without the human element.

This questionnaire is biased against atomic energy; and pro-pinko, moron rioters, Jane Fonda types, etc.

### *What Was Left Out*

I am shocked that a responsible organization would distribute a questionnaire like this with only one answering choice related to overpopulation.

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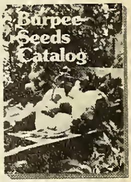

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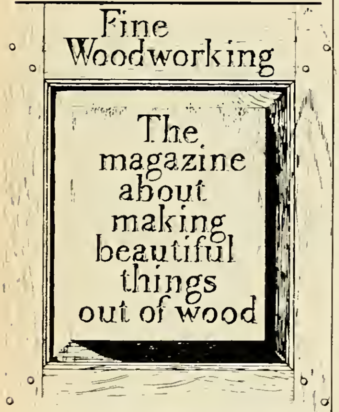

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quiz and leaving out the bedrock, basic reason why we are having an environmental movement and an ecological crisis in the first place.

I must protest the exclusion of the nuclear energy option from your list of energy alternatives in question 17. Among the presently viable methods of centralized energy production, nuclear fission is by far the *least* damaging to the environment.

Deregulation and market forces will solve energy problems.

I do these things [question 34 choices] but, I must admit, not primarily for environmental concern reasons.

I believe many persons who traditionally have been concerned about getting value for their money as a side benefit tend to protect the environment.

Does not adequately account for people who actively engage in ecological measures without organization membership.

### *Actions Taken or Considered*

I do not harass beneficial insects.

I hold large tracts of undeveloped land (at great expense).

I've turned down my thermostat. I wear synthetic furs.

It seems as if very few people are *really* interested in conserving. I even use my dental floss over and over again!

I am greatly in favor of modifying our home to make it more energy efficient, but I can't convince my parents.

Deny comfort and save? Okay. But where I live when the energy crunch first came, I and so many others saved electricity that the utility petitioned for a rate *increase* because so many less KWH had been sold, they needed more money. Got the increase too. So I'm stuck with my economies and paying more for them. Do you think I'm lying awake thinking of new ways to cut down?

Your questionnaire inspires me to actually join the Ecology Center in our town—doing instead of talking.

I would appreciate knowing ways to become more involved.

Unfortunately, I am too poor to have much to cut back on.

### *1970 and Now*

I was in favor of the ecology movement at first, but it has reached a point where our economy is being stifled by the movement. We are being reduced to a second-rate country by overly zealous opponents of coal and nuclear power, most of whom know nothing about either. Man is part of nature and has the right to improve his lot (within reason)! Be reasonable, not hysterical.

Ten years ago, I was marching and actively protesting. Now I'm older and don't think marching helps.

All of my environmental activities began in 1952 and ended in about 1970. By then I became convinced that mankind will not see the year 2000, no matter what we do now. It's too late, friends. You should have listened earlier.

### *On Activism*

Our hope is through action by existing organizations—church, state, political—not in creation of divisive splinter groups!

Too many individuals involved in environmental groups have very little technical knowledge about the various subjects they protest. This ignorance creates resentment among individuals who are knowledgeable in the technology involved with energy development and the environment.

Environmentalists are ruining America with their "no-spray" programs.

Let's be careful not to tear the fabric of our society in the name of ecology.

Are you trying to promote anarchy?!?!?!

We are a nation of LAWS. If you don't agree, please leave.

I find organizations to be as political and full of hot air as the opposition.

I would become an activist if my immediate environment was threatened by energy companies.

### *Eco-Philosophy*

I would like to state that this industrial society is doomed. The future is hopeless. What constantly amazes me is the amount of optimism. Do people have children because of optimism, or do they just need pets?

The poor nations won't wait for solar power.

Homo sapiens is a brilliant but doomed flash-in-the-pan.

Our problem is not really a shortage of energy sources. It is a shortage of faith in our ability to find alternate sources.

We have been given the stewardship of plants, animals—the environment. We must not use immoral techniques of "use and enjoyment." The central problem therefore is to determine what is a relationship of morality with the environment God has given us for our use and enjoyment.

This questionnaire overlooks the fact that all our problems are caused by the same basic attitude: personal unwillingness to subordinate personal rights to the general welfare. ☐

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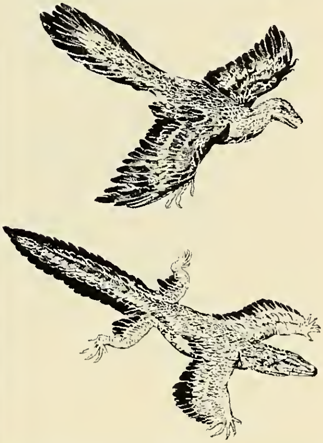

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# Chance Riches

*Perhaps our world really is only the result of randomness*

**by Stephen Jay Gould**

In literature, the idea of randomness is often coupled with chaos, lawlessness, or disorder to conjure up a vision of ultimate terror. In the *Essay on Man*, Alexander Pope evokes the image of an entire universe falling apart if its lawful order should ever be broken.

Let earth unbalanc'd from her orbit fly,
Planets and suns run lawless thro' the sky;
Let ruling angels from their spheres be hurl'd,
Being on being wreck'd, and world on world;
Heav'n's whole foundations to their center nod,
And nature tremble to the throne of God.

Pope's facile and hopeful solution simply banished the very idea of chance by a decree of faith:

All nature is but art unknown to thee;
All chance, direction which thou canst not see;
All discord, harmony not understood;
All partial evil, universal good.

Chance also got Darwin into trouble more than 100 years later when he granted it an important place in his evolutionary theory. Many critics, impelled by a knee-jerk negativism toward randomness, made no attempt to understand the strictly limited role that Darwin had awarded it. They argued: Darwin must be wrong; nature is so harmonious, animals are so well designed. This order cannot be the work of chance.

Darwin would not have disagreed. He constructed his theory in two parts, letting chance prevail in the first but strictly excluding it from the second for the conventional reason that chance could not, in his opinion, yield the order so prevalent in our world. In Darwin's theory, populations must first develop a large amount of heritable variation to provide raw material for the later, directing action of natural selection. Darwin viewed this pool of variation as random with respect to the direction of adaptive change—that is, if a species would be better off at smaller size, variation tends to arise with equal frequency at sizes both larger and smaller than the current average. The raw material for evolutionary change—and the raw material only—arises by a process of random mutation.

Natural selection then enters for the second part, and it acts as a conventional, deterministic, predictable directing force. Natural selection fashions the raw material of variation by preserving and fostering individuals that vary in adaptive directions. In our hypothetical population, small members will, on average, rear more successful offspring. Slowly, but inexorably, the average size of individuals in the population will decline.

Darwin expressed himself with admirable clarity, yet critics have been misunderstanding this fundamental point for more than a century, from the Rev. Adam Sedgwick (Darwin's geological mentor, not a dogmatic and antiscientific theologian) to Arthur Koestler. The litany is ever the same: Darwin must be wrong; order cannot arise from chance. Again, Darwin never said that it could. Chance only produces raw material; natural selection directs evolutionary change.

Evolutionary theory is now stirring from the strict Darwinism that has prevailed during the past thirty years or so. While critics have not seriously challenged Darwin's mechanism on its primary turf of explaining adaptation, they have rallied around a claim for pluralism. Must all evolutionary change be viewed as adaptation and ascribed to natural selection? Randomness has become a central focus for the critics because Darwin's strict dichotomy seems to be breaking. Randomness may not act only in generating variation; it may be an important agent of evolutionary change as well. The specter of chance is now truly intruding where Darwin's critics had falsely detected it before. Given both the surpassingly poor reputation of randomness in general (including the fear that it often generates), and the specific Darwinian tradition of limiting its role to the production of raw material only, this development in evolutionary theory is both exciting and, to many, disturbing.

I should enter some disclaimers, if only to reduce disturbance. Randomness is making its bid as an agent of evolutionary change, but it is not threatening natural selection in the realm of adaptation. The beauty and aerodynamic efficiency of a bird's

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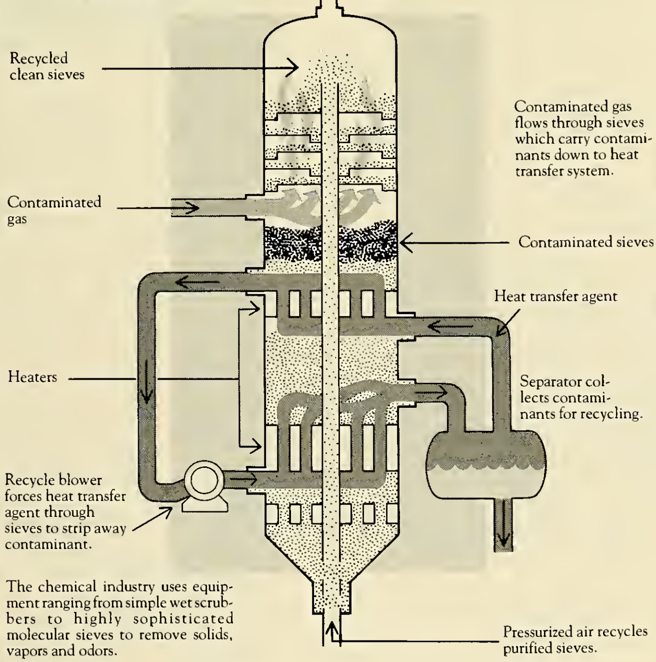
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wing, the grace and good design of a fish's fins are not lucky accidents. Also, I use the specific meaning that "random" has long maintained in evolutionary theory: to describe changes that arise with no determined orientation. I do not use it as a general metaphor for chaos, disorder, or incomprehensibility (more on this later).

Evolution operates at three major levels: populations change as the frequency of certain genes increases or decreases among their members; new species arise by the splitting of descendant populations from their ancestors; and evolutionary trends occur because some species are more successful than others in branching and persisting. Randomness is challenging the determinism of natural selection as a cause of evolutionary change at all three levels.

*The genetic structure of populations.* When natural selection operates in its usual way, genetic variation is reduced: the fit arise, in part, by the elimination of the unfit. The total amount of genetic variation in a population should represent a balance between the addition of new variation by mutation and the removal of unfit variants by natural selection. Since we have stores of data on rates of mutation and selection, we may predict the upper limit of variation that a population can maintain *if* selection acts upon all genes.

Techniques for measuring the amount of genetic variation in natural populations have only been available for the past fifteen years. Their first and primary result came as a surprise to many geneticists: most populations maintain too much variation for the usual claim that all genes are scrutinized by natural selection.

To be sure, natural selection does not always eliminate. In some cases, it may act to increase or maintain genetic variation. The most common mode of maintenance is called "heterozygote advantage." Suppose that a gene exists in two forms, a dominant *A* and a recessive *a*. In sexual species, each individual has two copies of the gene, one from each of its parents. Now suppose that the mixture, or so-called heterozygote *Aa*, has a selective advantage over either pure form, the double dominant *AA*, or the double recessive *aa*. In this case, selection will preserve both *A* and *a* by favoring the heterozygote *Aa* individuals.

But even these modes of preserva-

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tion have their limits, and many geneticists feel that populations still maintain too much variation for selective control. If they are right (and the issue remains under intense debate), then we must face the possibility that many genes remain in populations because selection cannot "see" them, and therefore cannot either mark them for elimination or remove other variants by favoring them. In other words, many genes may be *neutral*. They may be invisible to natural selection and their increase or decrease may be a result of chance alone.

Since "change of gene frequencies in populations" is the "official" definition of evolution, randomness has transgressed Darwin's border and asserted itself as an agent of evolutionary *change*. (This process of random increase or decrease of frequency is called "genetic drift." Contemporary Darwinism has always recognized drift, but has proclaimed it an infrequent and unimportant process, mostly confined to tiny populations with little chance of evolutionary persistence. The newer theory of neutralism suggests that many, if not most, genes in large populations are maintained by random factors.)

*The origin of species.* Species are defined as populations that are reproductively isolated from all others. Placed in contact with other populations, a true species will maintain itself as a separate evolutionary entity and will not amalgamate with another population by hybridization. The key question for the origin of new species then becomes, How does reproductive isolation evolve?

In the traditional view, an ancestral population is split by a geographical barrier (continents may drift apart, mountain ranges rise, or rivers alter their course, for example). The two descendant populations then evolve by natural selection to fit the local environments of their separated places. In due time the populations become so different that they will no longer be able to interbreed, should they reestablish contact. Reproductive isolation is a byproduct of adaptive evolution by natural selection.

During the past decade, the exclusivity of this mode has been challenged by a variety of new proposals advocating an interesting twist or reversal of perspective. They all argue that reproductive isolation can arise rap-

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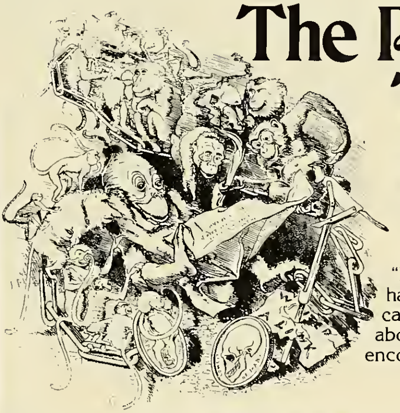
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idly as a result of historical accidents with no selective significance at all. In this case, reproductive isolation comes first. By establishing new and discrete units, it provides an opportunity for selection to work. The ultimate success of such a species may depend upon a later development of selected traits, but the act of speciation itself may be a random event.

Chromosomal speciation, the most popular of these models, deserves (and will soon receive) a column in itself, but for now, merely a sketch and an example. Taxonomists have discovered that many groups of closely related species do not differ much in form, behavior, or even general genetic composition. But they do display outstanding differences in the number and form of chromosomes, and these differences produce the reproductive isolation that maintains them as distinct species. An obvious, and old, hypothesis would suggest that each new species arises when a major chromosomal change occurs by accident and manages to establish a new population.

But this hypothesis suffers an obvious difficulty: the major change arises in a single individual. With whom shall it breed? The hybrid offspring of this mutant and a normal member of the population will almost surely be at a strong selective disadvantage. The mutation will therefore be swiftly eliminated.

Recent work on the structure of populations indicates that some reasonably common forms of social organization might facilitate the origin of new species by rapid and accidental chromosomal change. If populations are "panmictic," that is, if each female has an equal chance of breeding with each available male, then the chromosomal mutant cannot spread. But suppose that populations are subdivided into small groups of kin that breed exclusively with each other for several generations. Suppose also that these kin groups are harems, with a dominant male maintaining several females, and with brother-sister mating among the offspring.

If a chromosomal mutation arises in the dominant male, all his children will carry both the mutant (from their single father) and the normal form (from their various mothers). They will probably be at a strong selective disadvantage relative to normal offspring in other harems. But this may not matter, especially if they have limited contact with other groups. The

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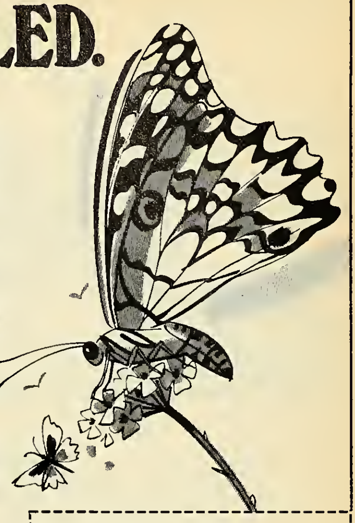
My colleague Guy Bush, of the University of Texas, tells me that horses provide, circumstantially at least, a strong case for chromosomal speciation. They all maintain the harem structure of kin breeding. Their eight living species (two horses, two asses, and four zebras) all look and act pretty much alike, despite some outstanding differences in external color and pattern. But their chromosome numbers differ greatly and surprisingly, from thirty-two in one of the zebras to sixty-six in that paradigm of the unpronounceable, Przewalski's wild horse.

*Major patterns of rise and fall in the history of life.* Many readers might be willing to accept chance at the smaller levels. A bit of slop for some "invisible" genes within populations, an accidental species here and there. But surely conventional reasons rule the grand ebb and flow of major groups in the history of life. Trilobites must not be as good as the "advanced" arthropods, shrimps, and their allies that now populate our seas. The hordes of brachiopods from times past must have been pushed out by other creatures, clams in particular, that look like them but work better. Dinosaurs must have been bad at something that mammals can do. At this level, natural selection must reign and life must improve.

The key to recognizing the essential fallacy of this argument lies in the facts of mass extinction. If groups slowly replaced other groups, some



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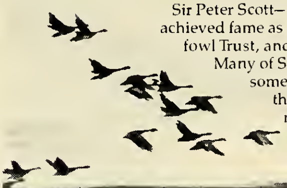

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gaining in species over millions of years while others lost just as steadily, a scenario of selective control might seem irresistible. But most groups disappeared during the episodes of mass extinction that have punctuated the history of life. This fact is not news. It has been acknowledged for decades but explained away with an assumption that differential mortality at extinctions must have a selective basis. The groups that roared (or even squeaked) through a holocaust must have survived for a reason. They were the tough guys, the good competitors. But some recent data on the extent of mass extinctions must call this comforting explanation into question.

The granddaddy of all extinctions occurred about 225 million years ago at the end of the Permian period. (We don't know why, although the coalescence of all continents at about the same time must have set the basic stage.) By wiping out many groups, permanently debilitating others, and allowing some to pass through relatively unscathed, this great dying set the fundamental pattern of life's diversity ever since. But how profound was the Permian extinction? An old and familiar figure states that half the families of marine organisms (52.0 percent to be exact) perished at that time. But families are taxonomic abstractions. What does 52 percent of families mean for species, nature's real units? (Inconsistent taxonomic practices and an inadequate fossil record prevent the counting of species directly. Families, as bigger units, are harder to miss.)

We can be sure that a removal of half the families requires the death of a much greater percentage of species. A family is not gone until all its species die, and many families contain tens or hundreds of species. The extinction of most individual species does not wipe out a family, just as, for example, the random excision of a single entry in a telephone directory rarely removes the name entirely—you'd have to bump off a lot of Smiths. How many species must die before 50 percent of families are gone?

David M. Raup of Chicago's Field Museum has recently considered this question (*Science*, vol. 206, 1979, page 217). The problem is not so easy as it might appear to be. If all families contained about the same number of species, then a simple formula would suffice. But variation is enormous. Many families contain only a single species. In this case, removal of the species also wipes out the family. Phone books contain their Zzyzzymanskis as well as their Wongs. Other families contain more than 100 species. We must know the empirical distribution of species per family before we can make a proper estimate. And we cannot construct an empirical distribution for Permian families because we cannot count the species directly.

Raup therefore made tabulations for a group that we do know well, the echinoids, or sea urchins. Echinoids include 894 species distributed into 222 genera and 40 families. How many species must, on average, be removed at random in order to eliminate 52 percent of the families? Raup considered this question both empirically and theoretically and came up with the astounding figure of 96 percent. If the rest of life maintains a distribution of species within families similar to the echinoids—and we have no evidence for major differences in the pattern—then the Permian debacle might have wiped out all but 4 percent of species.

Since estimates of living species in the late Permian range from 45,000 to 240,000, a removal of 96 percent would leave but 1,800 to 9,600 species as guardians of life's continuation. Moreover, as Raup argues, we have no strong evidence, despite intensive and specific search for it, of selectivity in the Permian extinctions. The debacle did not seem to favor any particular kind of animal—bigger creatures, inhabitants of shallow water, more complex forms, for example.

I am not entirely persuaded by the 96 percent figure. Echinoids may not be a good model for all of life. More important, Raup is assuming that the 52 percent figure is not artificially inflated by biases in the fossil record. We know, for example, that late Permian marine sediments are relatively rare and we may be missing some families that lived then simply because we have so few places left to look for them. Nonetheless, even the most conservative figures indicate a removal of 80 to 85 percent of all species.

I think that we must therefore face an unpleasant fact. If anywhere near 96 percent of all species died, leaving as few as two thousand forms to propagate all of later life, then some groups probably died and others survived for no particular reason at all. There are few defenses against a catastrophe of

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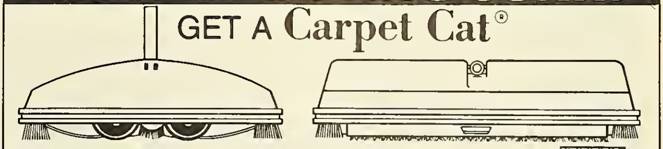

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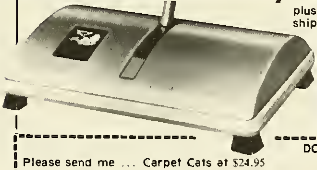

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such magnitude, and survivors may simply be among the lucky 4 percent. Since the Permian extinction set the basic pattern of life's subsequent diversity (no new phyla and few classes have originated since then), our current panoply of major designs may not represent a set of best adaptations but a group of fortunate survivors.

If we must admit randomness as an important agent of evolutionary *change* at all levels, what shall we make of it? Shall we surrender to despair and proclaim the history of life both chaotic and unknowable? Such a solution might embody Pope's equation of chance with disorder, but it would represent a great misunderstanding of the meaning of randomness, for two reasons.

First, chance may represent a good description of events at one level but not imply that the events are truly uncaused. Take the classic random event, a coin flip or the throw of a die. I imagine that each flip has a determinable outcome if we could (as we cannot) specify all the multifarious factors that enter into it—height above ground, force of the flip, initial side up, angle of first contact with the ground, for example. But the factors are too numerous and not under our control; an equal chance for each possible outcome is the best prediction we can make in the long run.

Perhaps the Permian extinction worked like a set of dice with few winning outcomes. Each species became extinct for a conventional local reason—this pond dried up, that estuary became too salty or suffered an invasion of a particularly efficient predator. But the reasons are so numerous and so beyond our ken that an equal chance for the removal of each species becomes a good prediction for the overall outcome.

Only in this way could many of the inventors of probability theory stomach their own creation, for they were conventional believers in deterministic causation and convinced theists unwilling to debar purpose from the world. Charles Bell, author of a famous work on the human hand as a reflection of God's wisdom through its intricate design, wrote in 1833:

> We say, in common parlance, that the dice being shaken together, it is a matter of chance what faces they will turn up; but if we could accurately observe their position in the box before the shaking, the direction of the force applied, its quantity, the number of turns of the box, and the curve in which the motion was made, the manner of stopping the motion and the line in which the dice were thrown out, the faces turned up would be a matter of certain prediction.

This explanation may be comforting, but I think we must face a second possibility. Perhaps randomness is not merely an adequate description for complex causes that we cannot specify. Perhaps the world really works this way, and many happenings are uncaused in any conventional sense of the word. Perhaps our gut feeling that it cannot be so reflects only our hopes and prejudices, our desperate striving to make sense of a complex and confusing world, and not the ways of nature.

What solace, then, can we have if solace we need. An answer, I believe, lies in rejecting another traditional belief, Pope's false equation of chance with a host of fearful cognates: disorder, chaos, lawlessness, unpredictability, and destruction. For contrary to popular belief, random means none of these. It may not, in the case of Bell's dice, imply a lack of causation. And even if it does in many cases, the result of a random process is not necessarily unpredictable disorder.

Random processes can yield highly predictable order. We have an elaborate theory for predicting the results of coin flipping, the archetypical random process. Suppose we flip six coins at once, over and over again. We can predict how many times the most common result of three heads and three tails will occur, and how many times the rare event of all heads or all tails will arise (one in sixty-four for each or one in thirty-two for either).

Admittedly, this is predictability of a different order. It works only for repeated trials in the long run. We can assign a probability to each individual flip, but we cannot determine a specific outcome. Nonetheless, the end result is ordered and predictable. Does not this kind of randomness offer sufficient comfort against the threat of chaos? Does it not even make for a more intriguing world? After all, it is this kind of chance that gives our own lives, and the course of human history, so much richness and interest. Call it by its older names of fortune or free will, if you like. Shall we deny a similar richness to the rest of nature?

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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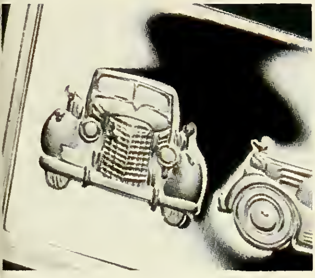

1938 Cadillac Convertible silver miniature illustrated above is approximately five times actual size to show fine detail.

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# Ireland's Bountiful Bogs

*Long a source of fuel and building materials, Ireland's bogs are also an archeological treasure house*

by Sharon Bohn Gmelch and George Gmelch

You stand looking out over a gently undulating sea of reeds, sedges, moss, and heather dotted by small islands of water. In spring this "sea" shimmers in green and gold; in summer, white cotton sedge flutters over its surface; in autumn it is mantled in russet and red. You move and the ground quivers underfoot. Only the scraw, the upper crust of fibrous turf and living vegetation, prevents you from sinking. Bog is 96 percent water; whole milk contains more solids.

Bogs cover three million acres, or roughly one-seventh, of Ireland's land surface. Found in almost every county, they are especially common along the western seaboard and in the broad plains of the midlands. Ireland's greatest natural resource, the bog is a source of fuel, building materials, and

Ronny Jacques, Photo Researchers

other products. But as a reminder of Ireland's poverty-stricken past, when the bog was nothing yet everything, it is also the country's most verbally abused feature. A "bog trotter" is a country bumpkin. To be a "sod" is to be thick and ignorant.

Since prehistoric times, turf from the bog has been cut for fuel in treeless parts of Ireland—in upland areas and along the windswept western coast. In other areas it was not commonly used until the sixteenth and seventeenth centuries when the British systematically cut down Ireland's remaining native forests: in the sixteenth century, to make military operations against elusive Irish "rebels" easier and to clear the land for farming and colonization by English and Scottish planters loyal to the British Crown; in the seventeenth century, for profit. The new landlords sold timber for use in the housing, shipbuilding, iron-smelting, and leather industries. Irish lumber also went to Welsh coal mines for pit props and to the Spanish and French wine trade for barrel staves. By 1700 the forests had been replaced by grass and weeds, and the land was used for rearing sheep and cattle. Turf became vital for domestic heating and cooking all over the country. It also became important in early industry. In the eighteenth century linen bleachers and brick makers used huge quantities of turf as fuel.

The basic methods of hand cutting, or winning, turf from the bog have changed little over the centuries. As soon as the crops are planted and dry weather begins, usually in April or early May, neighbors and family groups enter the bog to begin work. Traditionally, when almost all the land was held in common, the work was cooperative—neighbors gathered voluntarily to work one day for each of their number in turn. Today, each family has its own turf bank, or cutting face, but two or three families often pool their labor. Some manage to cut a year's supply of turf in two long days of work, but most people spend a week at this task.

Before any turf can be dug, the bog or section of bog has to be drained by digging channels to the nearest stream or brook. Then the cutting face can be opened. First the surface scraw, or parings, of coarse grass, heather, and moss is removed. Typically, a broad spade and sharp knife are used

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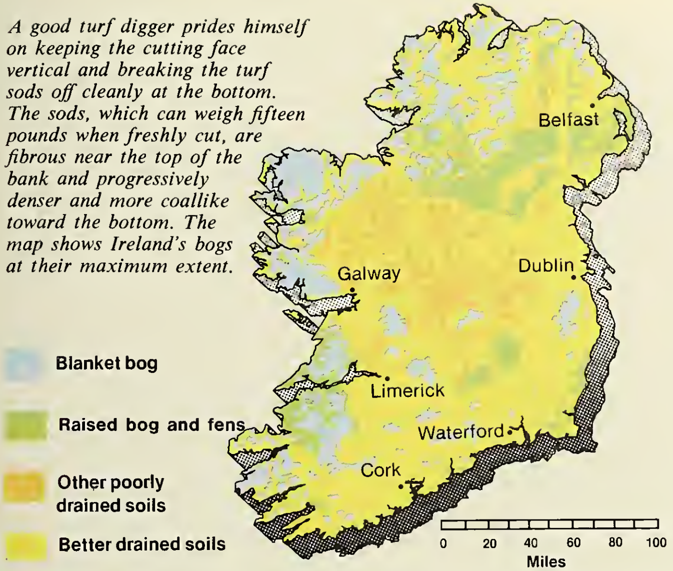
*A good turf digger prides himself on keeping the cutting face vertical and breaking the turf sods off cleanly at the bottom. The sods, which can weigh fifteen pounds when freshly cut, are fibrous near the top of the bank and progressively denser and more coallike toward the bottom. The map shows Ireland's bogs at their maximum extent.*



Joe LeMonnier

to peel back and cut the scraw. In some areas the scraw is burned to make its removal easier, but this practice is risky since fires can easily burn out of control. Permits are required in areas bordering government forestry projects.

Turf diggers now cut the prepared turf bank vertically from the top, using a method known as underfooting and a specialized spade called a slane (*sleán* in Irish Gaelic). Most slanes have a triangular wing set at right angles to the bottom of the narrow blade so that a complete sod can be detached with each stroke. While the exact shape and style of slane vary from one part of the country to the next—there are at least twenty regional styles—the one uniform characteristic is its light weight. Since a single water-saturated turf sod can weigh up to fifteen pounds when cut, slanes are made as light as possible. In some deep, lowland bogs, turf diggers use a different method, called breasting, in which they face the bank and cut horizontally into its side.

Most of the work is done in silence. Digging is hard, and no one wants to waste energy on talk. An experienced slanesman works with rapid precision, slicing the turf into uniform sods and rhythmically pitching them out of the bank. Great importance is attached to "keeping a straight face," that is, keeping the cutting bank vertical, and a poor digger is referred to as a clod cutter. Pride is also taken in ringing, or cleanly breaking, the turf sods off at the bottom. This is hardest to do when cutting the first layers of turf, which are looser and more fibrous. As the lower levels of the bog are reached, the turf becomes progressively darker, denser, and hotter burning. Freshly cut turf has the appearance and consistency of black butter. Ideally, a season's supply should contain both quick-firing top turf and coallike bottom turf.

Under favorable conditions, experienced slanesmen can cut a ton of turf in a single day. The freshly cut sods are caught by a barrow-man, who spreads them in a single layer on the surface of the bog immediately next to the cut or takes them by barrow or, more commonly today, by tractor and sledge to a special area, or spread field. There they lie for two weeks to dry in the wind and sun. The second stage of the drying process begins when the sods are propped against one another in footings, small pyramids designed to catch the wind. This work is traditionally done by women and children. A few weeks later, the sods are reversed, or turnfooted. During June and July they are further turned and stacked into larger piles, called rickles and clamps, for more drying. By August the turf has dried to about 30 percent water content and acquired a watertight skin. It is now ready to be collected, transported home, and stacked for a final time. Once, the custom was to stack the winter's supply of turf against the gable end of the house to help insulate the home and shelter the turf from the rain. A well-built stack, however, is designed with the outside row of sods tilted downward so the water runs off; this repels the rain while allowing the wind to enter.

In some parts of the country, low-lying bogs too wet to cut with a slane are won by molding or kneading the turf into balls. Alternatively, the wet turf is spread on the surface of the bog, marked with grooves, and later cut with a spade and dried through the usual process. No matter how it is done, hand winning turf is time-consuming, hard work. For every ton burned, more than seven must be cut and spread to dry and shrink. Nevertheless, measured against today's fuel prices and energy needs, the clean-burning turf is an inexpensive fuel for country and city dweller alike. A pole, or perch (an old English land measure roughly seventeen feet long by ten feet wide), of bog in the Dublin Mountains can be leased for less than £10 a year. Thus, a family can cut its entire year's fuel supply for about twenty-four dollars.

With its sweet-smelling turf fire burning continuously day and night, the open hearth was at the heart of traditional Irish country life. Meals were prepared in cooking pots suspended from a wooden or iron fireplace crane. Clothes dried and people and ailing animals warmed themselves in front of the fire. Before the development of chimney flues, open turf fires were especially effective in heating homes. Turf smoke was no doubt a problem, despite the draft-regulating mechanism of the double doors found in most traditional homes, but the low furniture kept heads below the smoke. Moreover, the smoke and heat helped keep the thatch and roof timbers dry in a notoriously wet climate, which is one reason the ceilings of traditional Irish homes are open to the rafters. Wooden or stone seats were built next to the hearth, the fireside seat being the place of honor. Stories were told around the turf fire, and omens of the future were glimpsed in the way ashes fell and cooled. Once the fire went out, the soul supposedly went out of the people of the house.

The importance of turf as a fuel has increased with the industrial exploitation of the bog. In 1934, the

Gordon Johnson, Photo Researchers

Turf Development Board was formed and began cutting turf with large, combinelike machinery, primarily in the raised bogs of the midlands. During World War II, all coal was diverted to industry, and the entire country depended on turf for fuel. Huge piles were dumped in Phoenix Park for Dubliners to use, and the country's trains ran on turf. In 1946, a semistate body, Bord na Mona (Irish Turf Board), was organized to meet Ireland's energy needs. Although it is a commercial enterprise, the Bord receives capital loans from the government and is obliged to take national energy needs into account. Today, it controls 170,000 acres of bog, employs more than 5,500 people, and produces more than five million tons of fuel annually. Turf-fired power stations supply about a quarter of Ireland's electricity.

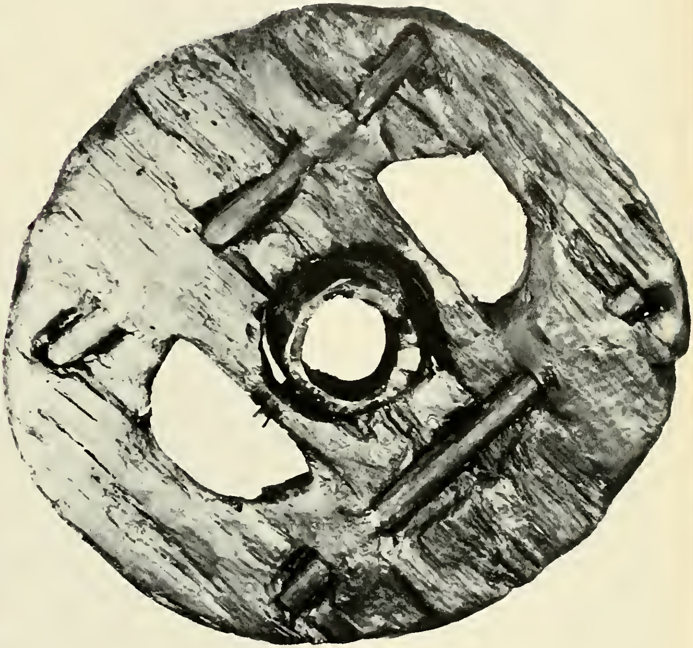
Bord na Mona has developed a highly mechanized system to harvest turf. Ninety percent is harvested in the form of milled peat. First, drainage ditches, four to five feet deep, are dug the length of the bog at intervals of forty-five feet. To let the water run off naturally, the bog is left for several years. When harvesting time arrives, eleven such parallel fields are worked as a single production unit. To shorten the drying time, a milling machine with a large, spiked drum slowly scrapes the surface of the bog to a depth of a half inch, leaving a layer of powdered turf. When this has dried it is then turned over by a machine known as a spoon harrow. In good weather, the turf may dry in less than a day, compared with many weeks for hand-cut sods.

When the turf is dry enough, a twin-bladed ridging machine scrapes it into a ridge in the center of each field. Each ridge is lifted by a mechanical harvester and carried by conveyor belt to the ridge in the adjoining field until all have been stockpiled in the central field. The stockpile is then covered with sheets of plastic. When turf is needed during the winter, the covering is removed, a temporary railway track is laid alongside the pile, and the turf is loaded for transport to the power station or briquette factory.

The entire milled-peat process takes three days, although rain at any time will cause a delay. In a typical season, mid-April to late September, twelve crops of turf can be won. Each cycle

Dick Rowan, Photo Researchers

*Left: After drying in a single layer for two weeks, turf sods are stacked, traditionally by women and children, in small pyramids, called footings, designed to catch the wind for further drying. Below: Dug up by turf cutters in 1969, this wooden block wheel, circa 400 B.C., is the oldest direct evidence for wheeled vehicles in Ireland.*

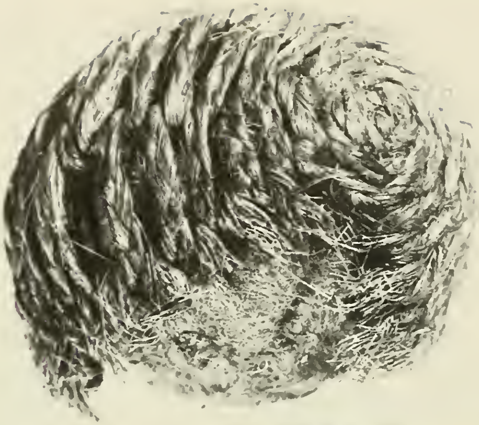


National Museum of Ireland

yields about six tons per acre. After the Soviet Union, Ireland is the world's largest producer of turf and such turf products as peat moss and turf briquettes. Owing to the great difference in land area, however, the gap in production between the two countries is large. It is said that more dried turf is blown off Soviet trains on their way to distribution centers than Ireland produces annually.

But the bog is more than a source of fuel. For centuries it has provided building materials and shelter. Until the turn of the century, Ireland's landless poor built houses of turf sods, much like those of the American prairie. The census of 1841, just before the Great Famine reduced Ireland's population by nearly a third, estimated that 40 percent of the country's 8.5 million people were living in one-room turf-and-mud cabins. During the famine itself, people seriously ill with infectious diseases, such as typhoid and diphtheria, were isolated in hastily erected, cone-shaped fever huts built of turf, with entrances "scarcely large enough for a dog to crawl through." Sweat houses, heated with turf fires and sealed with turf doors, were once commonly relied upon for cures. Usually, they were corbelled stone structures, but sometimes they were made entirely of turf sods or excavated into the side of a turf bank. Bog water was also believed to have medicinal properties.

Starting in the sixteenth century and lingering into the nineteenth, milch cows were taken to pasture on mountain bog each summer. Some family members, usually youths, went with the cattle and lived on the bog in temporary booley huts (from *buaile,* or "milking place") made of turf sods and boughs and roofed with long strips of closely grazed scraw, which had been peeled off the bog, rolled onto a stick, and carried like a carpet to the hut site. Some huts were circular in shape; others were square or rectangular. The latter had two opposite-facing doors through which the cows apparently passed one by one to be milked inside, a feature still found in many stone farmhouses in the west of Ireland. The booleys were often built in clusters, forming a temporary village where the inhabitants milked cows and sheep, cut turf, and made butter, which they stored in the bog. Seasonal nomadism greatly increased



*Left: This hair ball, found in a bog in County Limerick, was probably used in sporting events by the early Irish. Below: In the past, land was held in common and work in the bogs was cooperative. Today, although each family has a separate cutting face, several families, and generations, may share the work—and the relaxation.*

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the capacity of small Irish farms. Fields near the house could be used for crops or hay from May until October, when the cattle were away on summer pasture. At the end of the summer, the booley houses could be dismantled and used for fuel and building materials.

Surprisingly, the bog is also a source of wood. Preserved tree limbs and trunks, the remains of the forests that once covered the country, are abundant in Irish bogs; the most common species are pine, oak, and yew. From the mid-seventeenth century, rich and poor alike were dependent on bog wood for furniture, roofing timbers, flooring, wainscoting, carts, boats, and all manner of domestic and farm equipment.

To locate the wood, Irishmen walked out on the bog in the early morning before the sun had dried the land. Wherever the dew or frost was thin or absent, the ground was probed with a bog augur, a long iron rod. Once the size and soundness of the timber had been determined, a trench was dug and the ebony-colored, iron-impregnated wood was laboriously raised with ropes and chains. Today Bord na Mona views bog wood as a major problem and spends the entire winter removing it from the bog so that the machinery will not be damaged when work begins in the summer. The wood must be dragged away or chewed up *in situ* by a machine known as a stump miller.

In the past, pine found in the bog was especially valuable. Resinous pine splints could be used in place of candles and torches. Pine wood was also

made into rope. Straight-grained pieces were cut into long strips and hammered into stringlike shreds that were then twisted together to form long strands. When the strands were sufficiently long, they were twisted together to form strong yet supple two- and three-ply rope. Bog-deal rope was used to cord wooden beds and chair seats, to lash roofing timbers, to tie down thatch roofs in windy areas, to secure hay and corn stacks, to make burden ropes, halters, tethers, traces, and straps for back baskets.

In addition to preserving wood, the bog is Ireland's most important source of archeological remains—a storehouse of tools, weapons, ornaments, and ceremonial objects. The finds include stone axheads and querns, flint arrowheads and microliths, brass dishes, wooden bowls, pottery, bronze sword blades and leather-covered shields, boats, plank roadways, house remains, and ancient field boundaries. Bord na Mona employees are instructed to watch for artifacts in the bog and are given a bonus when they make a find. In 1977 an eleventh-century bishop's crosier, said to be on a par with the Cross of Cong and the Shrine of Saint Patrick's Bell (masterpieces of twelfth-century Irish metalwork and design), was spotted glinting in the sun in Lemonaghan bog by a Bord na Mona worker. Earlier this year, a monastic find of great significance was made. Hidden in a bronze bowl beneath the bog at Derrynaflan, County Tipperary, were a richly decorated chalice, paten, paten stand, and wine strainer. According to Brendan O'Riordain of the National Museum of Ireland, the pieces date to the eighth or early ninth century. The Derrynaflan Paten, now at the British Museum to be cleaned, matches, in the richness and sophistication of its ornamentation and design, the Ardagh Chalice, an example of Early Christian metalwork that is one of Ireland's most important national treasures.

Colman Doyle, Source

The most interesting finds, however, are undoubtedly the bog people—bodies found in remarkable states of preservation. The earliest well-documented discovery of a bog person anywhere in the world comes from Ireland. In 1781, in a small bog on Drumkeragh Mountain, County Down, the body of a very small woman, assumed to have been Danish, was found lying on a layer of gravel under a thick bed of turf. The body, its head facing the east and its feet turned toward the west, was still clothed in the garments worn at death: a skirt made of skin, a finely woven and decorated cape, a veil of light fabric, and a woolen blanket. Since that first find, at least twenty more bodies have been recovered. In all cases it was the acid in the water, combined with low temperatures and the absence of oxygen, rather than any preservative in the turf itself, that tanned the skin and organs and so preserved them for centuries.

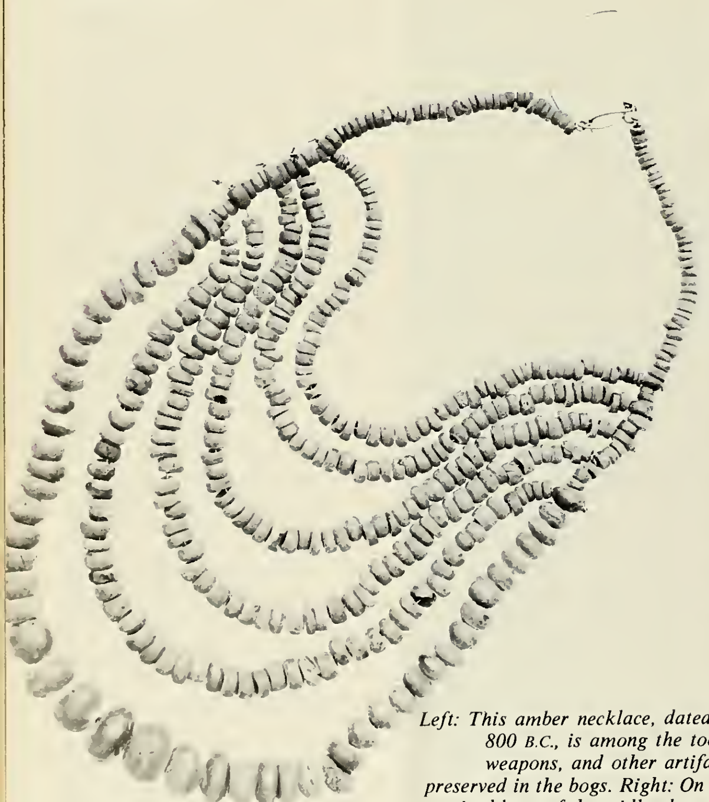
Less spectacular perhaps, but equally curious, are the numerous wood, cloth, and skin containers filled with "bog butter." As much as 100 pounds has been found in a single cache. There are many references from the seventeenth and eighteenth centuries to the Irish practice of burying butter in the bog to store and ripen it, thereby strengthening its flavor. Some folklorists, however, believe the practice predates the introduction of Christianity to Ireland in the fifth century and has a less utilitarian origin. According to E.E. Evans, past professor of geography at Queen's University, Belfast, butter was originally buried to appease the powers of evil and assure an abundant flow of milk from the cows in the pastures. Surviving folktales and stories are full of the magical properties of butter. In the west of Ireland lumps of butter were thrown into the lakes and springs through which the cattle were driven in order to restore the animals to health. In the last century, farmers took it to fairs and sold it as grease for cart wheels. When found today, the butter, which has the consistency and smell of ripe, crumbly cheese, is supposed to be sent to the National Museum in Dublin, along with other archeological finds.

Bogs are also the repository of other information about Ireland's past—pollen, seeds, and insects. From these, botanists, geographers, and zoologists have been able to construct a chronological sequence of Ireland's landscapes and fauna. This sequence has helped explain the origin of the bogs.

According to geographers such as A.R. Orme of the University of California at Los Angeles, Ireland has two main types of bog—the raised bogs of the central lowlands, which make up one-third of the country's bogland, and the blanket bogs of the western seaboard and uplands. Bogs began developing in Ireland's vast central plain about 10,000 years ago, after an improvement in climate resulted in the retreat of glacial ice. The landscape left behind was strewn with glacial debris. The hollows among the debris had impermeable floors of silt and clay and were filled with meltwater. On high ground, a subarctic tundra vegetation of lichens, dwarf birch, and willow grew, followed by forests of pine, yew, and oak. Aquatic and marsh plants grew along the lake margins, trapping inflowing muds. Slowly a layer of poorly decayed marsh plants built up to the level of the water table. The surface was colonized by sedges and grasses. In some areas trees also invaded the surface, creating in time a layer of wood-peat in the bog. But more often the water table simply rose as the marshes themselves obstructed drainage. Layers of decaying plant debris accumulated, forcing the marsh up and beyond the lake margins. Surface plants found it more and more difficult to reach down and extract nutrients from the soil beneath the growing bog. Beginning about 7,000 years ago, they were eventually replaced by sphagnum moss, which could thrive on nothing more than surface rainwater. As the growth of sphagnum moss caused the entire bog surface and water table to rise into a dome of spongy vegetation, a raised bog was born. Today, raised bogs range in area from a few acres to many square miles and average twenty-five feet in depth.

In the uplands and along the west-

National Museum of Ireland



*Left: This amber necklace, dated to 800 B.C., is among the tools, weapons, and other artifacts preserved in the bogs. Right: On the raised bogs of the midlands, more than five million tons of fuel are harvested mechanically each year. Turf from these areas will be gone in forty years; the land will probably be reforested or used for grazing.*

Dan Budnick, Woodfin Camp and Associates ern seaboard, bogs developed much more recently, roughly 2,500 to 4,500 years ago. In many areas they grew on a previously wooded landscape that was disrupted by Neolithic and Bronze Age farmers. Bog can be seen overlying the stumps of trees and covering field walls, graves, and even homestead foundations. According to some scientists, human activity played the leading role in the development of bogs. After the forests were cleared, the land was cultivated to the point of exhaustion, and a hard layer of impermeable iron and clay minerals gradually accumulated. Above this layer, drainage was impeded and marsh plants began to invade the abandoned and now waterlogged farms. Blanket bog then grew in much the same way as the raised bog of the central lowlands, except that black bog rush replaced sphagnum moss as the dominant plant in the upper levels of the bog.

Other scientists ascribe greater importance to the role of climate, especially the wetter conditions of about 2,500 years ago. Today blanket bogs average six to eight feet in depth and are best developed in areas with more than 250 days and 50 inches of rain a year. After heavy rains, bog lying on steep slopes can become unstable. Bog flows, engulfing sheep, farmlands, and roads, have occurred in several parts of the country.

What role will the bog play in the landscape and culture of Ireland in the future? The remaining life of the raised bogs now being worked by Bord na Mona is estimated at forty years. When all the turf is gone the reclaimed land under the cut away bog will be added to the nation's resources. In scale and potential it ranks with Holland's polders and the reclamation of England's fenlands. The two most likely future uses of this land will be for reforestation and as grassland for cattle and sheep. The first bog to be cut by the Bord has already been planted in Sitka spruce and Contorta pine and now supports a thriving young forest. Vast areas of mountain bog, however, will remain to be cut by hand in the traditional way for generations to come. Parts of the bog have already been designated as wildlands and will be preserved intact for the future—a reminder of, and storehouse of information about, Ireland's past. □

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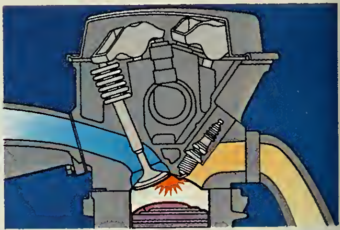

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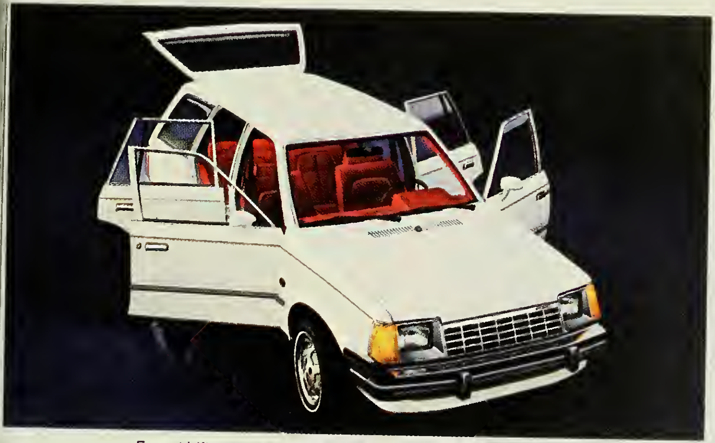

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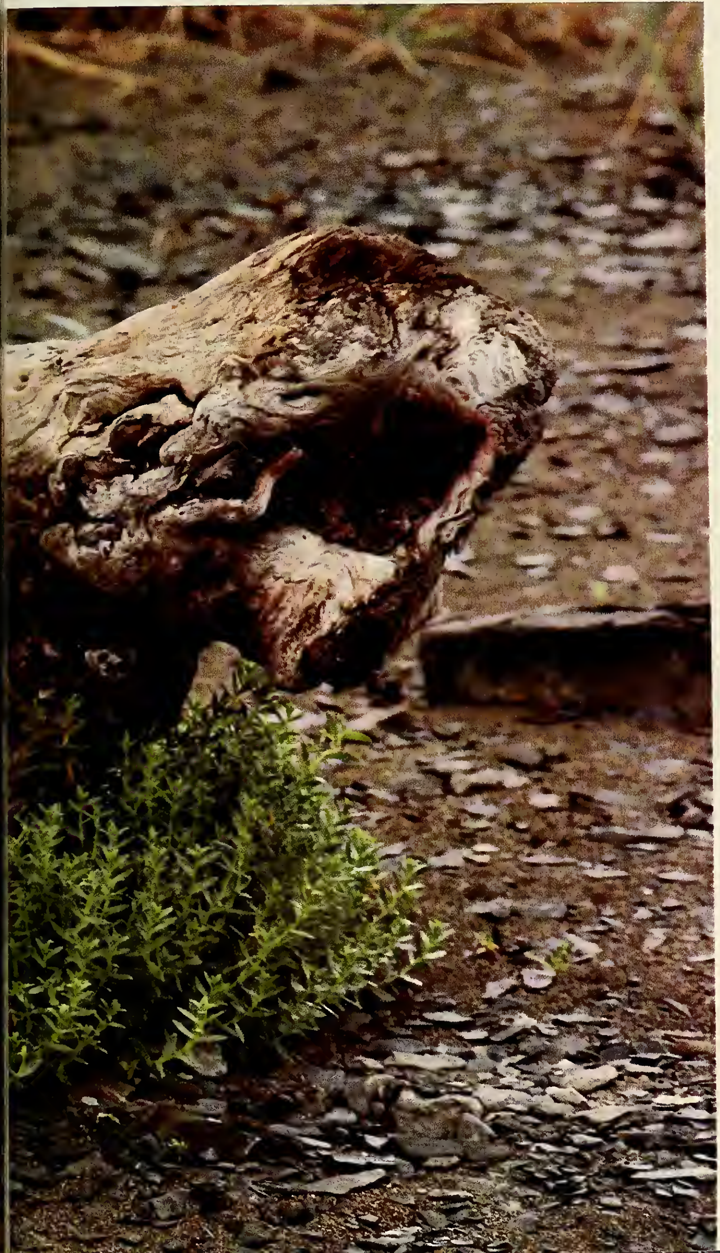
Photographs by Stephen J. Krasemann

# Fox Hunting

*Whatever the type of prey, the red fox has a way of hunting it. But mostly, this canid hunts like a cat*

**by J. David Henry**



The fox stopped suddenly, thirty yards in front of me. Turning broadside on the deer run, it lifted its head and perked its ears. Then it slowly stalked off the trail, testing each foothold, careful not to break a twig or rustle a dry leaf. With its eyes fixed on small movements in the grass, the fox froze, then slowly coiled into a deep crouch. It waited, adjusted its feet, then lunged and catapulted over a low shrub. While in the air, it beat its plumelike tail several times to the left to turn its body slightly in that direction. It landed as gracefully as it had launched itself, its forepaws touching down where the grass had been moving moments before. It had tried to pin a mouse to the ground, but the prey had escaped into a burrow, one of many escape hatches that punctuate a mouse's home range. After a brief search, the fox returned to the deer run and continued along it, searching for other prey.

What I had just witnessed was by now a familiar sight to me. Every day for a month, I had been observing red foxes from dawn to dusk as they eked out their living in the northern forest. I was ten pounds lighter now and finally fit enough to keep up with these lithe carnivores. This autumn was my sixth year of studying free-ranging foxes, and during this time I had seen them hunt more than four hundred times. The locale for my study was Prince Albert National Park, a 1,500-square-mile wildlife sanctuary located in the boreal forest of northern Saskatchewan. The park, one of Canada's largest, preserves a northern landscape, an area that

*The long, thin canine tooth protruding from the mouth of this scratching red fox is an example of a catlike feature. By pressing its canines into the prey, the fox can easily disable its intended meal.*

blends sphagnum muskegs with chapellike aspen and spruce forests and serpentine jack pine eskers. One-third of this area is water—large oval lakes interconnected by a maze of meandering creeks and rivers. The forest that grows in this area is part of the taiga—the northern coniferous forest that stretches across the continent from Newfoundland to Alaska. The red foxes found within the park have been protected from hunting and trapping for more than fifty years and as a result have lost their shyness of humans. I found that with the right combination of physical endurance and assiduous patience, I could follow and observe these flame-colored predators as they raised their pups and made a living.

My research on red foxes is only one of numerous field studies on free-ranging carnivores completed during the past decade. Wolves, lions, hyenas, cougars, coyotes, and lynx have been studied, to mention only a few. When these studies are compared, certain interesting patterns emerge. An understanding of these patterns clarifies many aspects of the hunting behavior of the red fox.

The studies show that wild cats (felids) and dogs (canids) use dis-

*Similar to cats, the red fox has a glistening layer of connective tissue on the innermost sheath of its eyeballs. This tissue layer, or tapetum lucidum, reflects light back out of the eye.*

tinctly different hunting strategies: felids are generally built for stealth and bursts of speed; canids for endurance and moderate speed. Felids stalk close and make surprise attacks. Canids approach prey openly, outdistance it during a long run, and finally pull it down. Consequently, the hunting adaptations of felids are different from those of canids. Cats have evolved soft foot pads for stalking, a fine sense of balance for a motionless posture during the stalk, and hooked retractile claws and great coordination in the forelimbs for capturing prey. In order to make their killing bite effective, cats have evolved short muzzles, strong jaw muscles, and daggerlike canines. Dogs possess different morphological specifications. They have evolved adaptations for speed and endurance that help them in cursorial hunting. In addition, certain canids show highly developed social behaviors that allow packs of these hunters to overpower and kill large animals. Predation by members of the dog family generally is not based on stealth but on the detection, testing, and running down of weak or vulnerable animals. Dog packs also dispatch their prey in a manner different from cats. They kill by repeated biting, mainly at the prey's hind end. When the prey is weakened from these wounds, the pack eviscerates the animal and commences feeding.

There are interesting exceptions to these general evolutionary patterns. For example, the cheetah is a cat that hunts in a doglike manner. On the African savanna it approaches prey openly, pursues it in a fast run, and finally knocks it over. As a result, the cheetah shows both structural and behavioral convergent evolution with canids: it has evolved an elongated, doglike muzzle; long legs and a deep chest; blunt claws and thick, hard foot pads—all adaptations for speed and capturing prey on the run.

The lion is another exception since it practices communal hunting. George Schaller, who studied lions on the Serengeti for four years, calls it "the most sociable cat." In this aspect it resembles the wolf and African hunting dog. The adaptive value of communal hunting seems to be the same for all three predators, namely, more efficient searching for prey, plus the abilities to capture large prey and defend the carcass against other predators that may try to steal it.

The lion and the cheetah show that ecological selection pressures can cause a species to deviate from the hunting strategies typically shown by its taxonomic family and evolve hunting strategies similar to another taxonomic group. When I began studying the red fox, I wondered where in these patterns the fox would fit. Basically, I set out to find out what kind of predator the red fox is.

A highly successful species, the red

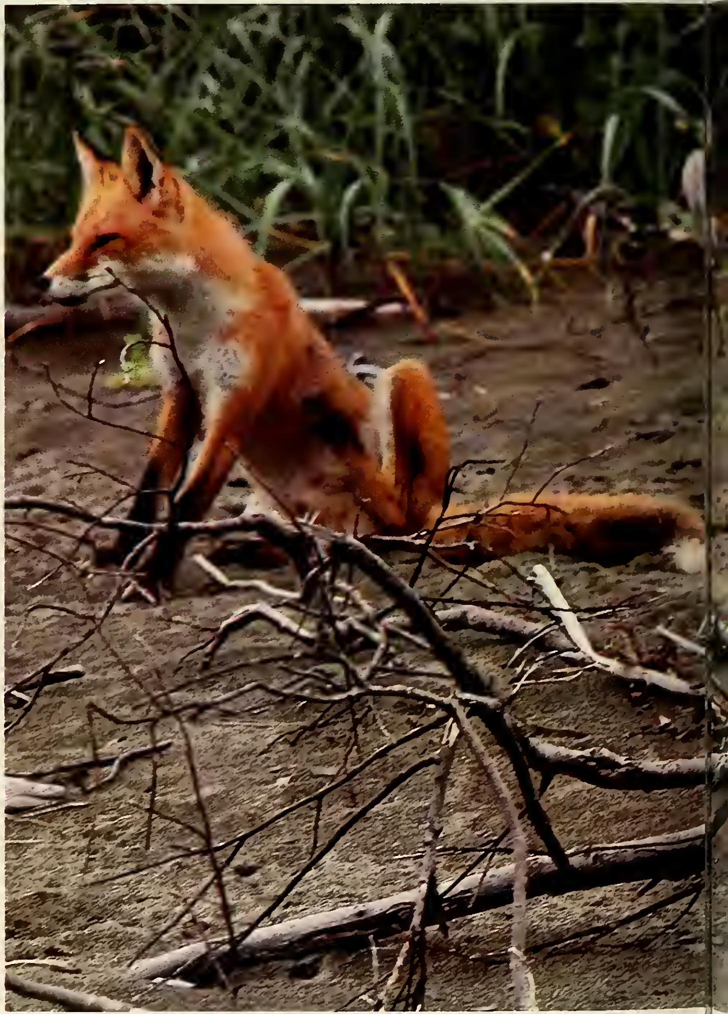
*Engaged in play, two pups become entangled while their mother remains alert and on guard. Pups, like kittens, hiss and spit at each other and at anything that approaches the den area.*

fox (*Vulpes vulpes*) is distributed throughout much of North America, Europe, Asia, and Africa, and has been introduced into Australia. Its food habits have been recorded in many locales. These studies consistently show that the red fox is not only a predator but also an opportunistic omnivore. It takes whatever food is most readily available, whether it be bird eggs, garbage, carrion, insects, or berries, but it usually relies on a few animal species as its real staples. Lagomorphs (rabbits and hares) and small rodents are generally the main items in the fox's diet.

The fox is not a miniature version of the wolf. Wolves are usually social pack hunters, while the red fox is a solitary predator. It hunts alone because of two intertwining conditions. First, the prey it catches are only large enough to feed one. Second, the best way to hunt these small prey is to stalk and use a surprise attack. Consequently, as the fox evolved into a specialized predator of small prey, it became progressively more solitary and like the smaller cats in its hunting behavior.

The fox's prey are not without their own defenses, which include alert vision, sensitive hearing, quick escape behaviors, camouflage coloration, stings, quills, and fetid sprays. In the ongoing evolutionary contest between predator and prey, both contestants are constantly evolving new adaptations to thwart the interests of the other side. In essence, predators and prey run an "arms race," with the prey developing new and improved mechanisms of defense and the predators in turn acquiring techniques to overcome these defenses. Over eons of time, this competition has led to the evolution of graceful, skilled predators and equally graceful, alert prey.

In the boreal forest the fox hunts animals that use four distinct sets of antipredator defenses. Consequently, the fox must use a different hunting strategy to capture insects, small bur-



rowing mammals, birds and tree squirrels, and snowshoe hares.

In a typical hunt for ground insects (crickets, grasshoppers, and beetles), and occasionally moths and flies, the fox travels along until it detects the prey in nearby grasses or on the forest floor, then casually walks over, bites down, and eats the insect. Usually it is as simple as that. Sometimes, however, the insect hops or flies away and the fox must search for it by poking its muzzle into shrubs or stamping one of its forefeet on the forest floor where it suspects the insect might be. After prodding the insect to move, the fox tries to locate it from small movements or rustling sounds. Interestingly, foxes were never observed using a foot-stamping action to crush an insect nor have I observed them using it in any other kind of hunt. Because these insects rarely show effective escape behaviors, the red fox exhibits a casual demeanor while hunting them. The fox's other prey offer more challenging contests.

The second strategy in the fox's hunting repertoire is used to capture voles, mice, ground squirrels, pocket gophers, and chipmunks—in short, any small mammal that escapes predation by fleeing into a burrow or under an object such as a rock or log. In the boreal forest, foxes usually hunt such prey while traveling along game trails, rabbit paths, hiking trails, or the edge of roadsides. The foxes hunt from these pathways apparently for two reasons. First, if the trail is wide enough to let in sunlight, dense vegetation grows adjacent to it and small mammals are frequently abundant. Second, foxes appear to use trails for quietness. The fox must approach the prey without being detected. If the fox makes a sound, such as cracking a dry twig, the prey will either crouch motionlessly, making detection difficult, or flee down a burrow or under a log.

The hunt begins with the fox walking down a trail. When it suspects a prey is adjacent to the path, the fox turns perpendicular to the trail, lifts its head and neck high, and stares intently. This elevated head posture is so characteristic of small burrowing mammal hunts that I termed it "head and neck in mousing position." A fox showing this head posture is almost always hunting.

If the fox cannot locate the prey, it may use a number of search tactics. For example, it may lower its head and sniff, trying to locate the prey from its scent. Or the fox may lift its head and rotate it, cocking it first one way and then another. These small head movements place the fox's ears at slightly different distances and angles from the sound. Henrik Österholm, a Scandinavian biologist, has shown that captive red foxes can locate a small rustling sound within one degree of its true location.

Alternatively, the fox may stalk to get closer to the prey. When stalking, the fox lowers its head and crouches down slightly. It moves slowly, carefully putting a forefoot down lightly on a spot and occasionally bringing it back up and choosing again. It tries to make as little noise as possible. To further reduce noise, the fox puts its hindfeet exactly where its forefeet had been.

After stalking for several yards, the fox assumes head in mousing position, and when it has located the prey, it crouches deeply and then lunges, arcing through the air. At the end of the lunge, the fox tries to pin the prey to the ground. Then it may dispatch the prey with several quick bites to the body or carry it off to a safe area where it plays with the prey like a cat with a mouse.

The fox's lunges are normally short (two to six feet), but they can be impressively long. I have observed red

foxes catapult fifteen feet through the air from a standing start and capture the prey. By way of comparison, the coyote, which is a third or more larger than the fox, has been observed to perform hunting lunges that are only eight feet or less in length. Foxes also show a preference for hunting the downhill side of trails. They may do this because by lunging downhill more area is placed within their reach. After observing several impressive downhill lunges, I made careful measurements and found that these foxes were airborne for a distance of up to twenty-five feet. Several adaptations, including proportionately long legs and a relatively light body weight, allow it to lunge these distances. The slender, long-legged silhouette of the red fox is a reflection of the adaptations that help to increase its hunting effectiveness.

When hunting birds and tree squirrels, red foxes rarely lunge; instead they stalk close to the prey and then charge in a crouched, dashing run. While I have observed more than a hundred instances of foxes hunting birds and squirrels, the foxes were rarely successful. In spring when these prey species are raising their young, they may be more vulnerable to fox predation, but on a year-round basis, birds and squirrels usually do not form a staple item in the fox's diet.

Foxes do not search for these arboreal prey but rather hunt them whenever they encounter them on the ground. When it spots a bird or squirrel, a fox immediately crouches so low that its belly almost touches the ground. Its neck is held horizontal, ears alert, and it remains motionless while staring intensely at its quarry. Then the fox "slink runs" at the prey, starting with a stalking pace, changing into a trot, and finally into a gallop. The fox maintains its low crouched posture throughout this charge. The last part of the slink run is a horizontal-thrust jump. It ends with the fox trying to catch the prey with a bite. The forepaw stab that foxes use to capture small burrowing mammals is not used to capture birds or squirrels.

A fox will sometimes hunt tree squirrels by stalking them in a curious stop-and-start manner. When stalking a squirrel in this way, the fox carefully watches the squirrel and tries to synchronize its movements with the prey's. Each time the squirrel faces away from the fox and begins to forage, the fox takes several quick steps in a deeply crouched posture, but freezes the instant the squirrel stops moving. The net effect is that the fox can mask its movements by synchronizing them to the movements of the squirrel. The fox appears tense and catlike when performing this synchronized stalking.

There is an interesting comparison between this type of stalking and the way a red fox stalks small burrowing mammals. The emphasis is different in each case. When stalking the small burrowing mammals, the fox puts its feet down slowly and is careful not to make any noise, but it moves its head about freely, alternately searching for a quiet route and then looking at the place where it suspects the prey is. On the other hand, during bird and squirrel hunts the fox may make little rustling sounds as its feet move across the ground, but it is always in a deeply crouched posture and its head and eyes are fixed on the prey as though tied to it by some invisible cord. These two stalking techniques appear designed to exploit different weaknesses in the antipredator defenses of different prey. In small mammal hunts the fox's stalking minimizes auditory cues that might alert the prey. During bird and squirrel hunts, stalking minimizes visual cues, while small noises are masked by the synchronization of the fox's movements with those of the prey.

Red foxes hunt rabbits and hares by stalking, followed by a "hell bent for leather" pursuit. This is the fourth hunting strategy that red foxes of the boreal forest show. In a typical hunt of a snowshoe hare, the fox crouches low to the ground and stalks slowly toward the prey while staring intently at it. Detecting the fox, the hare suddenly bolts and flees through thick cover while the fox follows in a bounding gallop. When it gets close to the hare, the fox attempts to bite it in the leg or rump. Frequently, at this point the hare will suddenly change direction. By zigzagging, it tries to

*talking a small burrowing mammal,*
*e red fox, left, tries to make*
*s little noise as possible.*
*puts its feet down slowly so*
*s not to break a twig or rustle*
*bit of dry grass. If the fox*
*as trouble pinpointing the*
*cation of the prey, it can*
*etect the presence of its quarry*
*hrough scent or sound. The rodent,*
*nally captured, bottom left, is*
*hared by two siblings, below.*

increase the distance between it and the fox. These actions may be repeated and the chase may cover a considerable amount of ground: the fox comes close; the hare zigzags and runs off in a new direction. Finally the hare either escapes into a briar patch dense enough so that the fox cannot follow or the predator gets a bite-hold on the prey. If the latter happens, the fox quickly pulls the hare off its feet and both collapse to the ground. The fox then quickly stands on its quarry, pins it to the ground with one or both forepaws, and bites it in the neck or head. Foxes are able to dispatch hares and rabbits quickly, perhaps because of the prey's slender neck and fenestrated skull.

There can be little doubt that the red fox is a bona fide member of the family Canidae. It shows all the diagnostic anatomical features that place it firmly in this taxonomic group. Evidence from the fossil record also confirms that the red fox is a canid. Yet many aspects of its hunting behavior are so catlike that I was struck by the possibility of convergent evolution between foxes and cats. Consequently, I conducted a search for features shared by red foxes and various small cats. This produced interesting results and has led to a new hypothesis concerning fox evolution.

Foxes and cats share numerous convergent features. For example, many fox species have long, catlike vibrissae on both the muzzle and the carpal (wrist) joints. These vibrissae are proportionately longer in these foxes than in other canid species. Field observations suggest that these whiskers function as tactile organs so that the muzzle vibrissae might help to guide the fox's capture and killing bites and the carpal vibrissae might assist the fox during stalking.

Foxes also exhibit proportionately long, thin canine teeth that resemble the long, daggerlike canine teeth commonly observed in cats. Many predators, once they have a small prey in their jaws, shake their head vigorously in order to immobilize and kill the prey. But red foxes and cats do not often show this behavior. Instead, they press their long canine teeth into the prey and keep exerting pressure until they damage the prey's central nervous system.

Red foxes also have catlike paws. For example, red foxes can flex and partially retract their front claws so that they are in fact semiretractile. Furthermore, the toe and foot pads of the fox are small and the rest of the foot is soft and covered with hair. I believe that these features not only reduce heat loss during winter but also function as adaptations for stalking by making the fox's feet more touch sensitive.

Convergent evolution between the fox and cat, however, is most striking in the anatomy of their eyes. Both animals exhibit a vertical-slit pupil and a highly developed tapetum lucidum. The tapetum lucidum is a glistening layer of connective tissue that has evolved on the innermost sheath of the eyeball. It reflects light back out of the eye and causes the eyes of foxes and cats to occasionally glow a luminous dull green even though no strong light is shining into them. This glistening membrane acts like a mirror behind the retina so that light passes over the retina twice instead of once. Using analogous photographic terms, the tapetum lucidum and vertical-slit pupil represent the evolution of a light-multiplying device with a shutter that can stop way down to accommodate bright sunlight.

Foxes also show many catlike features in their behaviors. For example, red foxes and gray foxes show a lateral threat display. A fox threatening with this display stands broadside, arches its back, erects its fur, and then charges broadside at the opponent in a stiff-legged gait. In addition, many of the fox's vocalizations are catlike. Like kittens, fox pups hiss and spit at each other and at disturbances. Adult red foxes exhibit a variety of high-pitched social calls that range from a short mewing cry to a loud, high-pitched alarm scream.

However, it is during hunting that the actions of a red fox most strongly resemble those of cats. For example, when hunting birds and squirrels, the fox—like a cat—stalks with its belly almost touching the ground or slink runs from cover to cover, crouching and waiting for its chance to ambush the prey.

What explanation is there for this convergent evolution between foxes and cats? Before a theory is offered, I must briefly examine the evolutionary history of these carnivores. Most paleontologists agree that canid and felid carnivores evolved from a common ancestral group, the miacids, approximately forty million years ago. These miacids were small weasellike or civetlike carnivores. They had an elongated body, a long tail, short limbs, and frequently, semiretractile claws. They were probably forest dwellers that preyed on insects and other small animals. Using this information, a theory can be advanced to explain the convergent evolution observed between foxes and cats. I suggest that foxes of the genus *Vulpes* differentiated early from the rest of Canidae and retained certain of their miacidlike characteristics, for example, a long tail, small foot pads, semiretractile claws, and long vibrissae. While the rest of the Canidae family evolved in a different direction, the foxes went on to show convergent evolution with Felidae and developed catlike hunting equipment in their morphologies and catlike hunting strategies in their behavioral repertoires. This convergent evolution is expressed to varying degrees among fox species and may be most strongly expressed in the red fox.

What ecological selection pressures would cause foxes to evolve in this way? As many food habit studies show, foxes in general and the red fox in particular hunt many of the same kinds of prey as small cats. To escape both fox and cat predation, their prey probably use similar antipredator devices. To capture their prey, foxes and cats have evolved a number of convergent features. Both have a well-developed tapetum lucidum and vertical-slit pupil for good nocturnal vision; long vibrissae; long, thin canines and the lack of head shaking for an effective killing bite; a fine sense of balance; soft, hair-covered feet; and quick reactions—all of which facilitate stalking and a surprise attack.

Consequently, the red fox, and perhaps other fox species, are as much exceptions to the canid taxonomic lineage as the cheetah and lion are to felid lineage. The red fox is a member of the Canidae, but because it hunts the same prey as small cats, the red fox has evolved to become a very catlike canid. □

*Rodents, rabbits, and hares are the staples of the red fox's diet in Prince Albert National Park, but foxes also eat a wide variety of other items, including birds, berries, insects, and carrion.*

# Welcoming the Wind

*Distinctive architectural forms tap desert winds for power and comfort*

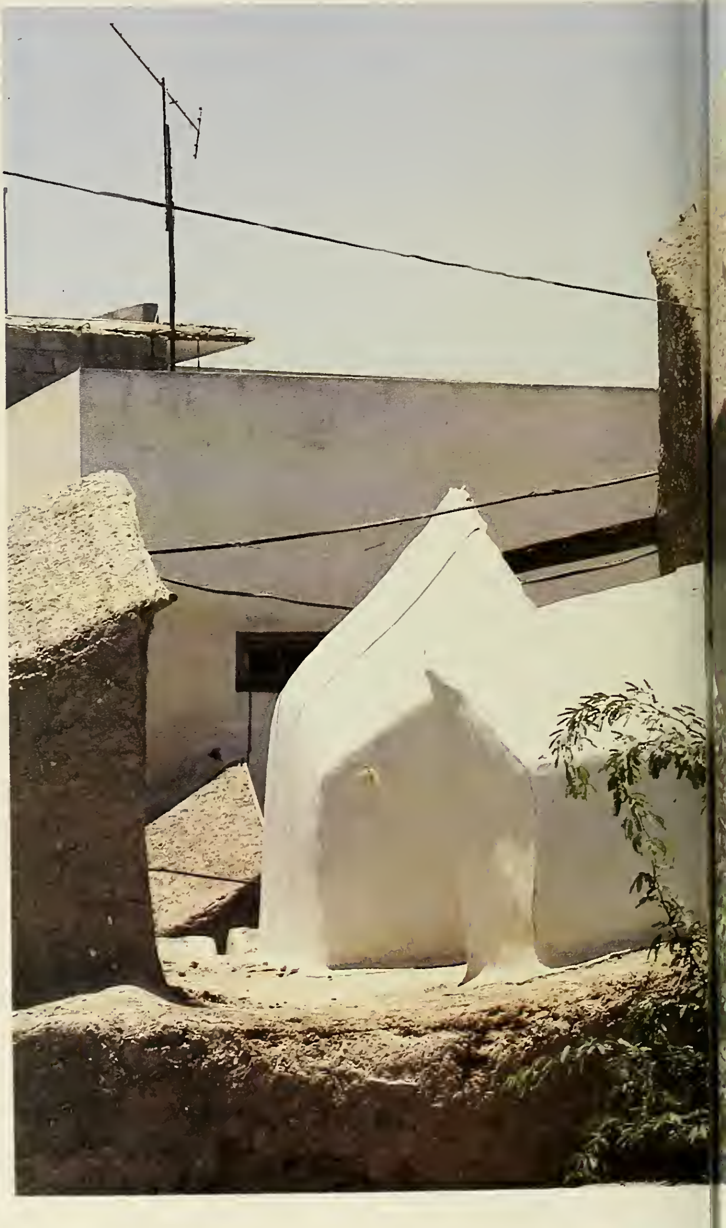
**by Jean-Louis Bourgeois**

From zephyr to tempest, the wind has many moods. Most architecture shelters us from it. But in some regions of the world, intriguing forms of traditional architecture welcome the wind.

The wind blows hard in western Afghanistan. Sweeping south from the Kyzyl-Kum steppes of inner Asia, a torrid gale known locally as the "wind of 120 days" and "the wind that kills cows" occurs almost daily from June through September. Often reaching 100 miles an hour, this wind blows hardest in Seistan, a dry, hot region that extends across Afghanistan's southwestern border into Iran.

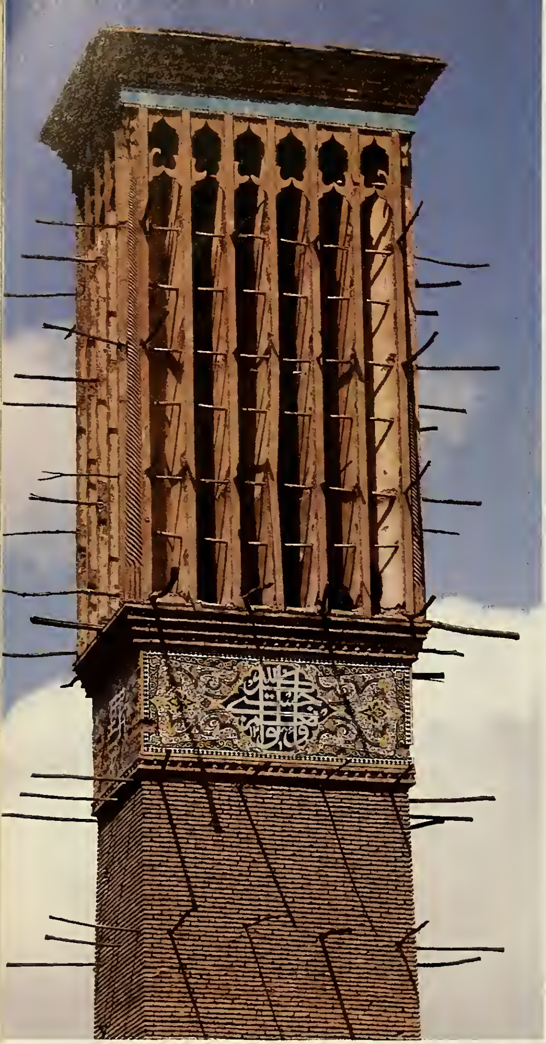
Seistanis turned their local meteorological scourge into a benefit. They were the first people to channel the wind's wild energy into work. During the ninth century, or before, Seistanis invented the windmill. They were perhaps inspired by horizontal, wind-driven prayer wheels, which whirled in Tibet and Mongolia at least as late as one hundred years ago. The sails of the initial Seistani mills almost certainly rotated horizontally like the millstone, thus bypassing the need for a gear to translate vertical into horizontal torque.

Not until the late twelfth century did windmills—with the familiar, vertically rotating sails—appear in Eu-



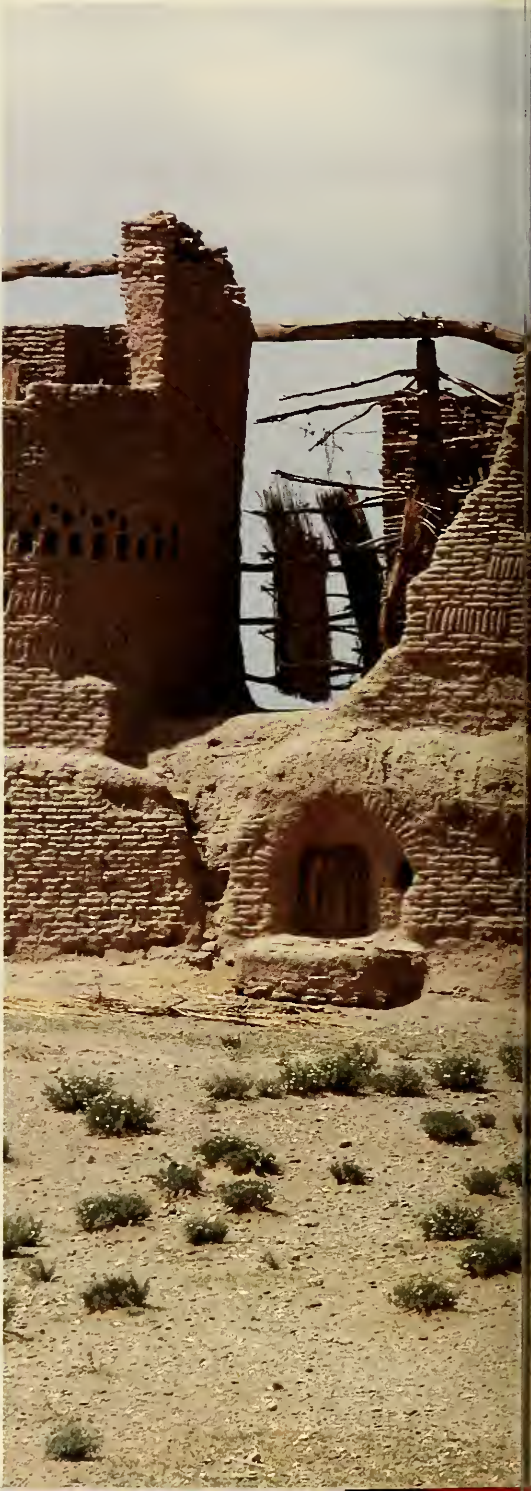
*The wind catcher is a simple but effective device that admits a refreshing breeze indoors. Its design and orientation are tailored to local meteorological conditions. In Tatta, a large town in the Sind region of southern Pakistan, wind catchers (shown here from the back), rise from roofs to swallow a southwest wind. Blowing from the sea, the cool wind, dried by its travel over the intervening desert, brings relief during the hot months of April through June.*

Carollee Pelos



Bruno Barbey, Magnum

*Above: In regions that lack a prevailing summer wind, many buildings are cooled by wind towers, which range from simple to grand. This one, in southeastern Iran, bristles with scaffolding poles, left in place to facilitate repair. The tall slots accept light breezes from any direction. At night, if the air is still, the tower acts as a ventilator. Air warmed in its mud-brick shaftways escapes upward, drawing cooler night air into the building through doorways and windows. Right: Horizontal windmills, such as these in western Afghanistan, recall the earliest windmills, invented more than one thousand years ago in the nearby region of Seistan. Rising from the domed mud-brick roof of the lower story, a mill's shaft bears sails of matted grass. The upper story is open at the back and on half of the side that faces the wind. The closed half of the front shields the returning sails. When the wind is fierce, additional mats are placed in the wind slot to keep the sails' speed down so that the millstones will not burn and blacken the flour.*



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rope. And not until the late sixteenth century did they reach La Mancha, in central Spain. Probably because their whirling sails were new and strange to Cervantes, windmills outraged the gallant Don Quixote.

Early windmills prompted not only comical pique but also admiration and even wonder. Of Seistan, "the land of wind and sand," a tenth-century chronicler writes, "there is no place on earth where people make more use of the wind." A thirteenth-century commentator even compares the Seistanis' power over the wind to that of the early wind-master Solomon, the first person in legend to travel—with his entire court—on a flying carpet. Today, working horizontal windmills have almost disappeared, superseded by diesel-powered mills.

In the late nineteenth century, a local ruler in central Iran tried to import the horizontal windmill. At considerable expense, he built a huge mill to raise water. But the mill never pumped a quart—local winds were far too light to turn its sails. This mismatch of regional wind and vernacular wind device is rare if not unique. The rule is an exquisite pairing, best shown in traditional structures using the wind, not for energy, but to cool.

The strength of a region's wind governs the form and size of openings both to receive the wind and to vent it. In and near Seistan a powerful wind blows from a single direction, and the area's wind scoops are small and, facing into the wind, look northwest. Small ventilators are needed only over kitchens. Upper Egypt's prevailing summer wind is mild, so ventilators—which help draw the breeze through a building—yawn at least as large as the quite large wind catchers. In fact, in the latter region, free-standing porches actually face away from the wind, their back walls pierced by relatively small openings. The flow of air over and around the porch creates a low-pressure area within that pulls air through the openings. The reverse orientation would not allow sufficient venting to prevent the air inside from going stale.

In Iran's central plateau and along the Persian Gulf, torrid temperatures and light breezes have inspired thermal ingenuity. Wind towers—tall to reduce the admission of dust—are topped by slender openings up to thirty-five feet high. The giant slots, connected to individual passages within the tower's shaft, function alternately as intake and outlet. Facing all four quarters, they can harvest the slightest, most fickle breeze. After sundown, should the wind die, the heat stored in the tower's mud bricks warms the air, which—being less dense than the cooler surrounding night air—rises. This creates a draft that pulls a refreshing night breeze through doorways and windows.

In southern Pakistan, in a portion of the Sind region's flat desert, a southwest wind blows from April through June. Dry, steady, and cool, it is a blessing, arriving with the area's most brutal heat, when the daily maximum temperature averages 105 degrees Fahrenheit. The wind is moderate, so wind openings are large and ventilators infrequent. In a typical village hundreds of wind catchers reach high into the sky like giant periscopes, to clear the "wind shadows" of neighboring rooflines. They all turn their backs to the winter wind, which blows from the opposite quarter and is not needed indoors in cool weather.

Like that of most indigenous architecture, the history of lower Sind's wind catchers is obscure. Local tradition states only that their use is "very old." Their first written Western notice seems to have been by an English traveler who, visiting the city of Hyderabad in 1815, observed that wind catchers occurred on every house "from the governor's palace to the lowest hovel."

Southwest of Hyderabad, the large town of Tatta boasts wind catchers on the great majority of its houses. Most consist of just three flat planes and an anchoring post. But there are interesting variants. Sometimes, wind catchers do not rise from the roof but are incorporated into a building's highest story. Many are double or quadruple, the east–west axis two or four times the north–south axis. In a few cases, the ratio can be as much as seven to one. Below this type extends a long, narrow "wind room" whose entire ceiling is a wind catcher.

An elegant, twenty-year-old house in Tatta boasts a wind room twenty-eight feet long. On its lee wall, four windows and two doors can be opened in any combination to regulate the flow of air into two bedrooms and through them out to an open court and its wide colonnade. In the colonnade's four walls are twenty-one doors with transoms. Eleven wind catchers and two ventilators cool the entire house. Kitchen and toilets—and their odors—are to the lee of all bedrooms.

All wind catchers have a metal grate to prevent entry into the house via the roof. Except for the very large ones above wind rooms, all also have trap doors. Propping these at different angles governs the amount of air admitted. In winter they are shut. In multistoried houses, a shaft conveys the breeze to rooms on lower floors.

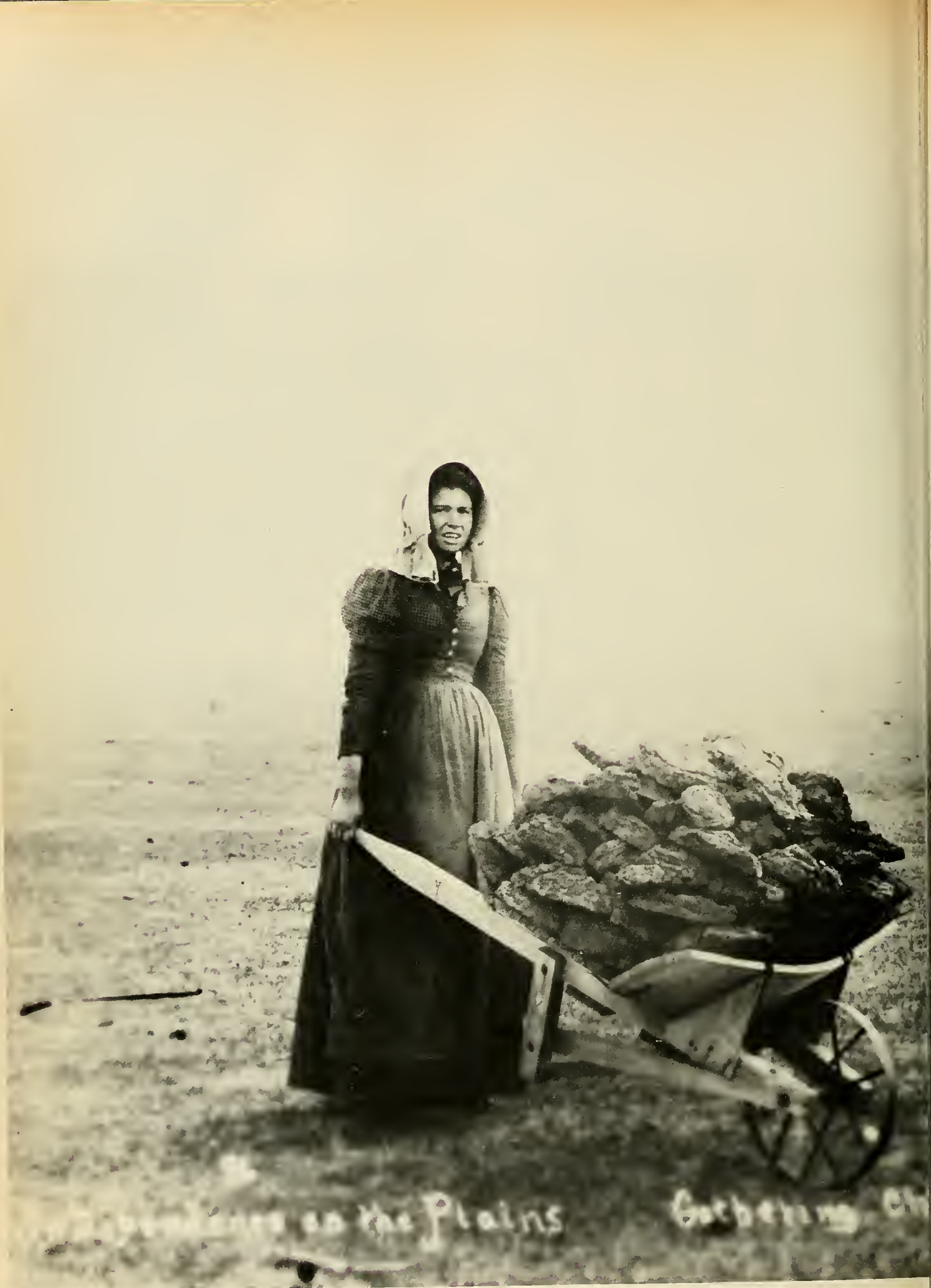
Wind-catcher technology runs the gamut from traditional to industrial. In many wind catchers, a base of sun-dried mud brick supports a deflecting plane of wood, the whole sheathed with a layer of mud mixed with dung and straw. More modern ones have a base of kiln-dried bricks, a plaster sheath, and a deflecting plane of corrugated steel supported by a wooden frame. The most modern ones are entirely concrete.

Another type of traditional air conditioning is used from northern India through Iran. A suitable local bush is woven into a loose, thick mat or packed into a frame, placed outside a window or door, and continuously or repeatedly drenched with water. A breeze evaporating the water can easily cool a room 15 degrees. In Indian cities, a special electric fan may replace the breeze. The entire appliance, a clever wedding of traditional and modern technology, is called a "desert cooler."

Architecture to catch a cooling wind is very old. Ancient Egyptian houses featured triangular wind devices. At least 1,200 years ago wind scoops caught the sea breeze on buildings in Peru. As rising fuel costs make industrial air conditioning prohibitively expensive, age-old ingenuity may come to the rescue. Meteorologically appropriate areas of the world would do well to adopt specific wind devices—ecologically sound forms of air conditioning at once cheap, efficient, and often beautiful. ☐

*The typical rooftop wind catcher in Hyderabad, in southern Pakistan, is elegantly constructed of two supporting planes and a third, deflecting plane, set at an angle and anchored by a post. A trapdoor can be adjusted to reduce or cut off the flow of air to the rooms below.*

Albert Moldvey, Editorial Photo Services

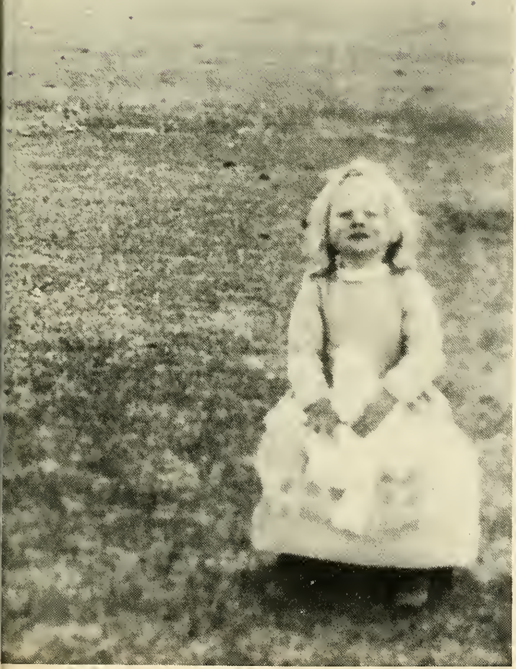

on the Plains
Gathering

The Kansas State Historical Society

# No Fuel Like an Old Fuel

*Plains pioneers were quick to learn the virtues of "buffalo wood"*

**by Roger L. Welsch**



John Janovy's popular book, *Keith County Journal,* based on his observations as a field biologist in one of the sandhills counties in western Nebraska, opens with an essay on termites. This strikes plainsmen as peculiar, because termites eat wood, and there are no trees to speak of in Keith County. Still, termites have lived there for millenniums despite the lack of trees. Termites persist because they are adaptable, and in the case of Keith County, termites have come to live in and eat cow chips. Before that it was buffalo chips, and before that God only knows.

The Plains pioneers of the late nineteenth century found a land so sparsely populated with trees that guidebooks for various overland trails could instruct travelers to go westward "to the tree." My children have pointed to Colorado's mountains and asked me, "Which one is Pikes Peak, Dad?" but no child on the trails of the Great American Desert had to ask, "Which tree, Dad?" One great cottonwood that grew on the banks of Nebraska's Platte River gave its name to a town that clustered to its shade—Lone Tree. Eventually, that tree was hacked to pieces by travelers who, after two weeks' journey, apparently recognized that if their children were ever to grow up remembering what wood looked like, some had better be taken along. As novelist Wright Morris later wrote in his *Works of Love,* it appeared that forests, strictly speaking, were not going to be a part of the Nebraska landscape.

When white settlers first came to Indiana, the region was heavily forested—perhaps by as much as 60 percent—primarily with hardwoods such as oak, walnut, and hickory. Farther west, Illinois was roughly 40 to 50 percent forested; Iowa 18 percent. In the Plains state of Nebraska, trees covered only 3 percent of some 77,000 square miles. Forestation was concentrated along the eastern border, in the Missouri River valley. Some oak and walnut grew along eastern Plains streams, and pockets of cedar lay hidden in low, wet swales. On the islands of the Platte River, cottonwood, ash, and cedar found shelter from the annual, ravaging grass fires. But other than that, there were very few trees.

What trees there were, were grabbed up by the earliest settlers, who understandably wanted to build houses as God had meant houses to be built—of logs. But two or three houses per thousand square miles and the trees suitable for construction were used up. Younger trees were cut for railroad ties or for fuel. My guess is that by 1880 Nebraska was closer to 1 percent forested than 3 percent.

So the folk architects of the region turned for construction materials to sod, baled hay, skins, and used railroad ties. The houses could not be built of newly felled wood because there was none, nor of stone because there was none of that either, nor of brick because there was nothing with which to fire it. Even where there were log buildings on the Plains, there were no chimneys. Generations of women had cooked over open wood fires in brick and stone fireplaces and ovens. Now there was not only no more cod or cabbage or potatoes but there was also no fireplace. To be sure, the cast-iron cookstove was to the open fireplace what a microwave is to a cookstove, but the change, even if for the better, was disconcerting.

Even more traumatic was the change in the fuel used for cooking. Those same German, Norwegian, and Czech women who had for centuries scolded their men and children about wearing field shoes into the house, thus tracking bits of manure into the sanctified living quarters, were now reminding those husbands and children not to bother coming in unless they brought with them a good load of manure. Brought that manure into the kitchen, mind you. Like the termites, people had to adapt.

All manner of fuels were used throughout the last quarter of the nineteenth century and the first quarter of the twentieth on the northern Plains. I have collected recipes, for example, that specify the number of corn cobs to be added at intervals during the cooking process in a cast-iron stove. In "Little Old Sod Shanty on the Claim," the homesteading bachelor sings:

> When I left my Eastern home, a bachelor so gay,
> To try to win my way to wealth and fame,
> I little thought that I'd come down to burning
> twisted hay
> In my little old sod shanty on the claim.

Especially designed stoves compacted grass into drums to be fed slowly into the firebox flame. Children were put to work making "cats"—braids of grass tied in an overhand knot. When asked about the health of his wife, one settler replied that what with her carrying in cats and him carrying out ashes, he had not had much of a chance to inquire after her health. Sunflowers were grown for their woody stalks; people even tried to use sod as an uncured peat since it was, after all, primarily grass roots and humus. The remarkable effectiveness of sod, baled hay, log, and railroad-tie houses fortunately mitigated any extreme requirements for heating fuels, but the problem remained critical when it came to cooking fuels.

Earlier travelers on the Oregon and Mormon Trails had also had to deal with the problem. In the song "Crossing the Plains," an obvious veteran laments:

> There's not a log to make a seat along the river Platte,
> So when you eat, you've got to stand or sit down square
> and flat;
> It's fun to cook with buffalo wood, take some that's newly
> born,
> If I knew once what I know now, I'd a gone around the
> Horn!
>
> The ladies have the hardest time, that emigrate by land,
> For when they cook with buffalo wood, they often burn
> a hand
> And then they jaw their husbands round, get mad and
> spill the tea,
> Wish to the Lord they'd be taken down with a turn of
> the di-a-ree.

And the Mormons sang, in "Whoa, Ha, Buck and Jerry Boy!":

> There's a pretty little girl in the outfit ahead,
> Whoa, Ha, Buck and Jerry Boy!
> I wish she was by my side instead,
> Whoa, Ha, Buck and Jerry Boy!
> Look at her now with a pout on her lips
> As daintily with her finger tips
> She picks for the fire some buffalo chips,
> Whoa, Ha, Buck and Jerry Boy!

The process was simple enough. Bess Jacobsen wrote to me in a personal letter her memories of gathering cow chips on the Plains:

> I wish I had a dollar for every C.C. I "forked" into a wagon, unloaded, and stacked.... We started out with a wagon, old

*In the late 1890s, cow chips were dutifully collected by the sons of George Dew, a pioneer rancher in Cherry County, Nebraska.*

tub, and a couple of yards of rope, and a pitchfork. We would drive out on the range where the cattle had grazed. After the chips dried on the hot sand for a few days they were like dry wood. We would tie one end of the rope to the tub and the other end around our waist, fork up the chips, throw them in the tub, when full, empty them into the wagon until we had gathered a good load.

Take them home, stack them igloo fashion until the stack was almost as high as the house. That way they stayed dry all winter, as we used them from the bottom of the stack. Altho they burned very fast and it took a lot of them, they sure gave off a lot of heat. They didn't have an unpleasant odor, just about like burning grass, which they were.

The qualities of buffalo chips had been discovered in the mid-nineteenth century. The chips burn evenly, hotly, and cleanly, with little smoke and no odor. But it was the idea of the thing. Mari Sandoz evoked the times in her novel *Old Jules*:

> Different as these Kinkaiders were, they were united by two common bonds. They all wanted a railroad; still held meetings, consumed enormous amounts of chewing tobacco and time, and went home optimistic. The other was as most bonds are: a common need. Fuel. With no tree closer than the Niobrara River or the brush of the Snake, little money, and wretched roads over twenty to forty miles of sun-drenched or snow-glazed hills to the nearest railroad, wood and coal were out of the question. Cow chips were the solution. Most of the settlers had lost all the qualms that curse the fastidious long before they reached the hills. Barehanded they took up the battle, braving rattlesnakes, which upon acquaintance failed to live up to their reputation for aggressiveness. City women encased their still-white hands in huge gloves and, with a repugnance no extremity could completely erase, endured the first few weeks somehow. The music teacher wore gloves to the last.

Nebraska State Historical Society

It was also Sandoz who later noted that before long it was only the most fastidious woman who bothered to dust off her hands between stoking the stove and mixing the biscuit dough. Little wonder. Charlie O'Kieffe, in his *Western Story*, wrote as follows "for the edification of housewives who may never have cooked with buffalo chips":

> Stoke the stove, get out the flour sack, stoke the stove, wash your hands, mix the biscuit dough, stoke the stove, wash your hands, cut out the biscuits with the top of a baking powder can, stoke the stove, wash your hands, put the can of biscuits in the oven, keep on stoking the stove, until the biscuits are done.

Gathering cow chips or buffalo chips quickly became a way of life. Children gathered chips on their way to school and on the way home. The ardent suitor courted, not with a box of candy or a bouquet of posies, but with a bushel basket of chips, a sure key to the practical maiden's heart. It was reported that Nebraska girls could be identified by their overdeveloped right toes, which resulted from their hooking chips and turning them over to see if they were "done."

An old-timer told me that late one fall, when there was still not sufficient fuel gathered for the cruel Nebraska winter, he and his brother were confronted by their anxious father. The father thought that to increase the supply of chips perhaps the boys should gather some that were not fully "cured." "Boys," he asked, "are you getting them 'close' enough?" "Dad," the elder brother responded, "some of them are so close they're still warm."

Sylvia Grider, a Texas folklorist, has told me that the formula in that state is "flat and white, not round and brown."

Family and community contests were invented to encourage the understandably reluctant children at their task. In Enders, Nebraska, I was told by one homesteader's child that in his family, the child who brought in the biggest cow chip during the annual fall cow-chip harvest would get a silver dollar. After a dismal sequence of failures, he determined to win the contest by thinking well ahead. During the summer he gathered a formidable quantity of very fresh cow pies and fashioned a single gargantuan cow flop that would have put Paul Bunyan's Babe to shame. He rolled the seasoned cartwheel proudly home that fall, fully expecting to take the prize, only to find that the unappreciative family not only disqualified him from that year's contest but never trusted his entries from that point on and to this day will not buy life insurance from him.

As was the case with the multitude of miserable burdens inflicted on settlers of the northern Plains, chips too became the nucleus for a storm of esoteric jokes. I am not at all sure whether the survivors managed to laugh or the laughers managed to survive, but the close association is undeniable.

Euphemisms for the fuel were meant less to disguise the true meaning than to point quite explicitly to the repugnance of the situation. Chips were called cow wood (as in *bois de vache,* corrupted to "bushwa"), Hereford lump, Nebraska oak, Kansas coal, platters, and flop. Some observed that this was a wonderful land indeed where the cows cut the wood and the output of the family Bossie was measured less in gallons of milk or percentage of butterfat and increasingly in cords. Cooking with manure was said to eliminate the need for pepper. The Nebraska Federal Writers Project files contain a story from Grant Tibbles, who homesteaded south of North Platte, Nebraska, in 1888:

> Once I'd been three days in the canyons after fuel and my grub was gettin' low. I built a fire by moonlight out of cowchips and was sittin' there eatin' my supper when I dropped a piece of biscuit. I didn't want to waste it so I carefully picked it up and popped it into my mouth. Lordy, how I sputtered and spit. In the moonlight old cowchips is about the same color as biscuit.

A canon of esthetics developed, as in this account by James J. Lynch of Cherry County, in the archives of the Nebraska State Historical Society:

> The heavier the grass was where the load was dropped, the better the chip was for burning, and especially the seasons had much to do toward their value for burning: those in the fall where the cattle had access to eat the abundance of plums that grew along the creeks in those days, had much to do with their value. When you found a chip that was about half plum pits you had a very much desired burning article. Those chips burnt just like coal and generated a very hot fire and lasted far longer than the ordinary chip.

Joe Lansden, The Herald-Democrat, Beaver, Oklahoma

*A champion cow-chip thrower poses by a wagonload of what early settlers gathered for fuel.*

Joe Lansden, The Herald-Democrat, Beaver, Oklahoma

*A Great Plains community that celebrates its pioneer heritage is Beaver, Oklahoma, home of the annual World Championship Cow Chip Throw.*

Just as the song "Little Old Log Cabin in the Lane" could be adapted to Plains conditions by being changed to "Little Old Sod Shanty on the Claim," where there was no water the song "The Old Oaken Bucket" could be made appropriate to the new geography with heartfelt—if marginally literary—revisions:

A Ballad on Nebraska Fuel

How dear to the eyes in the land of Nebraska,
Where coal can't be bought and wood isn't found,
Where ozone is fresh as it is in Alaska,
Are the big piles of cowchips that lie on the ground—
The fire-kindling cowchips, the hash-cooking cowchips,
The corn-saving cowchips that's scattered around.
How ardent we seize it, with eyes that are glowing,
And say to ourselves that it cooks very well
And then when we're waiting and punching and blowing,
How rich are the fumes that arise to the smell!
The needful old cowchips, the odorous cowchips,
The hash-cooking cowchips so rich to the smell.
When we think of old woodland with hills that are "yaller,"
Where folks must be taught to toddle around,
We turn with disgust from its "aguery" pallor right back
Where both climate and cowchips are found—
The soggy old cowchips, the rich-scented cowchips,
The hash-cooking cowchips that out here are found.
When crops are a failure and stock is a-dyin',
And corn for our fuel cannot then be found;
When hauling our water, we're freezing and crying,
How welcome the cowchips that out here are found—
The genuine cowchips, the bonafide cowchips,
The pure-blooded cowchips that out here are found.
In this glorious country with water below us:
Where ozone in short takes the top off the ground;
Where hail storms benumb us and blizzards o'ercome us,
Are the soul-cheering cowchips that lie on the ground—
The time-honored cowchips, the homesteader's cowchips,
The fume-giving cowchips that lie on the ground.

(From the files of the Nebraska State Historical Society. Originally published in the September 13, 1934, *Hooker County Tribune* with the notation that this "melodious blank verse was found recently in the family Bible of the Hugh Elliot home northeast of Thedford and then thought to be a half century old. It bore the initials R. W. L.")

Prescott Webb devotes not a single line of his classic *The Great Plains* to cow chips. James Olson's *History of Nebraska* gives them a scant short paragraph. Frederick Jackson Turner writes of barbed wire and windmills but ignores the cow chip. It is, to be sure, a sensitive subject for a serious scholar, and yet without an appropriate consideration of the humble cow chip, one can understand neither the history nor the folklore of the Plains frontier.

*Folklorist Roger L. Welsch is associate professor of English and anthropology at the University of Nebraska at Lincoln.*

# Ice Sheets and Ice Melts

*Sea level rises and falls as enormous blankets of frozen water wax and wane, changing the face of the land*

**by Cesare Emiliani**

There are floods and floods. Some, like the great floods of the Huangho (Yellow) River in China that killed almost a million people in 1882 and almost four million in 1931, are produced by unusually rapid snow melting or heavy rains. Others are produced by a sudden rise of sea level (by so-called tidal waves, which have nothing to do with tides), by submarine earthquakes, or by storms such as hurricanes. Examples of the latter are the Galveston flood of September 8, 1900, which killed 5,000 people, and the floods of August 1960 that hit Bangladesh and killed 10,000 people. Still other floods are the result of the collapse of natural or artificial dams or of landslides that end up in a lake, causing its water to overflow.

A spectacular example of the collapse of a natural dam was that of the ice tongue that dammed the fossil Lake Missoula during the last Ice Age about 14,000 years ago. The sudden draining of the lake resulted in the formation of the "channeled scablands" in southeastern Washington state, a landscape similar to that observed on Mars, which, apparently, was also produced by giant floods. An example of a landslide ending up in a lake is the one that filled up Lake Vajont, an artificial lake in northern Italy, on the night of October 9, 1963. Water flowing over the dam inundated the villages below and killed 1,800 people.

All these floods, destructive as they proved to be, were local. Although different giant floods, occurring at different times and in different places, may have been woven into the legend of a universal flood (for example, the deluge described in the Old Testament), a truly universal flood, affecting all coastal areas of the world at the same time can be produced in only two ways: by raising the floor of the ocean or by melting the ice on the land.

There have been times during the geologic past when large portions of the continents were covered with shallow seas. Geologists recognize two periods when flooding of the continents by the sea was particularly widespread: one during the late Ordovician, about 450 million years ago; the other during the late Cretaceous, about 80 million years ago. The late Ordovician marine invasion (or transgression, as geologists call it) was the largest flood of all. In the United States, only present-day Minnesota and Wisconsin, western Montana and northern Idaho, and small areas in Colorado and the Southwest, remained above water. All the rest was flooded. In late Cretaceous time, much of the West and the southern states were below water. These great transgressions resulted from global changes in the topography of the deep-ocean floor, most likely from the development of global submarine ridge systems. The system that broke up the supercontinent of Pangaea 180 million years ago is still active today. The Mid-Atlantic Ridge is part of it.

Submarine ridge systems take tens of millions of years to develop. Heated by the decay of radioactive elements and isotopes, rocks in the interior of the earth expand and overturn like a slow-boiling mass of porridge. A single overturn may take 200 million years. When hot rocks are brought up close to the earth's surface, heat does not escape continuously. Rather, the crust slowly swells up and then cracks, permitting seawater to penetrate it. As the water penetrates, heat is rapidly removed and the crust settles back until sufficient heat accumulates to start the process again.

The slow rise and more rapid sinking of the sea floor along the mid-ocean ridge system result in the sea slowly advancing onto the land and more rapidly withdrawing. Geologists studying marine deposits on land are familiar with these "sedimentary cycles." The sea may take several million years to advance on land and only a couple of million years, or less, to withdraw. Because vast areas of the continents are low lying, the sea can advance deep within a continent.

While marine transgressions and regressions produced by topographic changes on the ocean floor are very slow processes, much more rapid global movements of the sea can be produced by the waxing and waning of ice on land. During much of its geologic history, our planet has been free of ice. Only four major epochs of glaciations have occurred during the past billion years: in the late Precambrian period (about 600 million years ago); in the late Ordovician (about 450 million years ago); during the Carboniferous and the Permian periods (from 300 to 250 million years ago); and during the late Cenozoic era (from 15 million years ago to the present). The present ice epoch is still in progress, as shown by the huge ice sheets in Antarctica and Greenland.

Glaciation occurs when continental masses are at or near the poles. In Permian times, for instance, South Africa was located right on top of the South Pole and was surrounded by South America, Madagascar, India, Australia, and Antarctica. This great continental mass, called Pangaea, accumulated a huge ice sheet that grew and shrank in size many times during its 50 million years of existence. The repeated waxing and waning caused the sea to advance and retreat many times over low-lying continental areas, including much of the American in-

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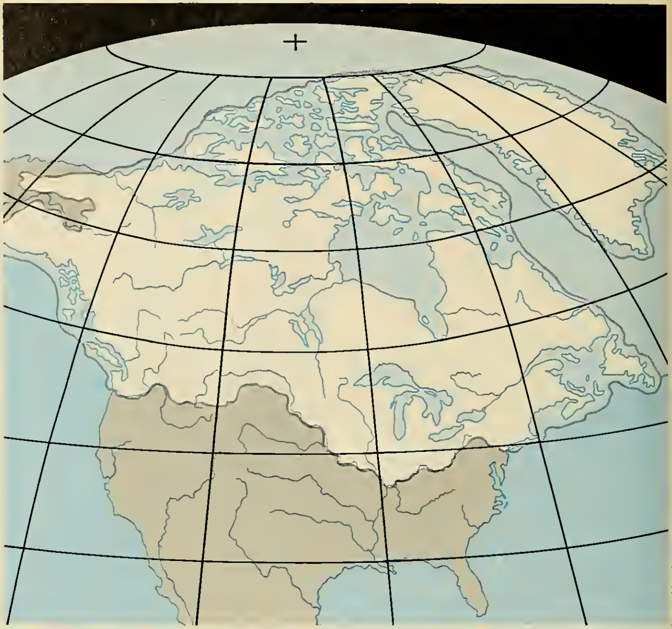
*During the last glacial maximum, some 20,000 years ago, sea level was about 300 feet lower than at present and a sheet of ice almost two miles thick covered vast areas of the North American continent.*

**The Laurentide Ice Sheet**



Joe LeMonnier

terior, which then had an equatorial position. Vast marshes formed in the interior where poor water circulation led to the preservation of decaying vegetable matter. With time, the layers of decaying matter became coal that now constitutes our largest energy resource.

As Africa and the other continental masses slowly drifted to their present positions at lower latitudes, Antarctica drifted to the South Pole. The present ice sheet began forming on Antarctica about 40 million years ago, but did not reach the shores of that continent until about 16 million years ago. There it has been sitting like a giant ice cube, chilling the entire ocean and keeping the temperature of the abyssal and deep water close to freezing. The abyssal fauna had to adapt to this new condition; those animals that couldn't, are not alive today. Meanwhile, the northern continents kept drifting northward until, today, they are jammed against each other around the North Pole.

About 4 million years ago, the Central American isthmus rose from the sea and blocked the exchange of water between the Pacific and Atlantic oceans. The result was a dramatic decrease in the amount of warm Atlantic water entering the Arctic and the appearance of ice in the surrounding lands. An ice sheet developed over Greenland at that time and has apparently been maintained there since. This further cooled the high northern latitudes and ice began appearing over both Canada and Scandinavia.

Ice forms under specific conditions of temperature, landscape morphology, and precipitation. A glacier is like a slow river: ice accumulates where snow falls and flows to areas where snow may not fall at all. The ice front is maintained when there is an equilibrium between the rate of ice flow and the rate of ice melting. This equilibrium is dictated by many different parameters, including the precessional, or wobbling, motions of the earth's axis that cause the seasonal amount of solar radiation falling at high latitudes to change with time. The result is a periodic advance and retreat of the ice. Ice retreated from Canada and Scandinavia between 14,000 and 6,000 years ago but in both areas small glaciers and icecaps have re-formed during the last 5,000 years.

The water to form ice on land can only come from the sea. The formation of ice on land, therefore, lowers sea level, and when it melts, sea level rises. If all the ice now present on earth were to melt, sea level would rise about 200 feet, enough to flood the Mississippi Valley all the way up to Memphis. During the last glacial maximum, about 20,000 years ago, sea level was about 300 feet below the present, and vast areas of the continental shelves of the world were dry land. The Bering Strait was also dry, permitting humans to walk from Siberia to Alaska and populate the New World.

The story of the advances and retreats of ice on the northern continents since the Central American isthmus was formed has been revealed by the study of deep-sea sediments. The shells of tiny animals and plants living in the surface water of the ocean accumulate in these sediments. If conditions were to change (if, for instance, temperature were to decrease because of an ice advance on the continents), the type of shells accumulating on the ocean floor and the isotopic composition of their carbonate material would also change. The study of these changes has shown that there have been about thirty periods of ice advance and retreat during the past three million years, roughly one every 100,000 years.

The process of ice growth is very slow, taking most of the 100,000 years' time from glaciation to glaciation. This is so because the growing ice cools the ocean, and the cooler, denser water sinks and is replaced by warmer water. The process of deglaciation, on the other hand, is very rapid: because ice meltwater has low salinity and density, it floats and can be rapidly heated by the sun. The melting of ice on a global scale, as during a period of deglaciation, is the most rapid way we know of to produce a global transgression, or a universal flood. The last one followed the last deglaciation and peaked between 12,000 and 11,000 years ago.

The amount of ice covering the North American continent during the last glacial maximum 20,000 years ago was truly phenomenal. Consisting of the huge Laurentide sheet to the east and the smaller Cordilleran sheet to the west, the total ice sheet was larger than that covering Antarctica today. Needless to say, environmental conditions on the continent then were vastly different from those of today. By analogy with contemporary Greenland and Antarctica, the thickness of the Laurentide ice sheet must have been some two miles. The greatest thickness was over Hudson Bay, but the ice was almost as thick as far south as the northern shores of the Great Lakes. Growth of the ice sheet through snowfall must have been very vigorous because of its relative proximity to the warm waters of the Gulf of Mexico and the western North Atlantic. Melting along the southern margin must have been equally vigorous in order to maintain equilibrium. Most of the Laurentide ice sheet drained down the Mississippi Valley, with the Missouri, Mississippi, and Ohio rivers contributing to the lower Mississippi Valley vast amounts of the muddy water that emerged from under the ice sheet.

Because of its high density from the heavy load of fine sediment particles abraded by the ice from the bedrock, the ice meltwater was capable of carrying pebbles as large as a fist all the way down the Mississippi Valley to Louisiana. Transport of these coarse materials was enhanced by the drop in sea level, which caused the rivers to cut into their own beds and resulted in a steeper downriver gradient. Sediment transport must have been particularly great in the late spring and summer, following the seasonal melting of winter snow and ice, and flooding must have been common.

The fine sediment left on flood plains was picked up by the wind and strewn over vast portions of the midcontinent, forming the deposit known as loess. Windstorms were probably common during the glacial maximum because of the steep temperature gradient between the ice sheet to the north and the warm seawater to the south and southeast. In the west, great lakes draining adjacent mountain glaciers were formed. These lakes, covering large areas of Utah, Nevada, southern Oregon, and eastern California, are now dry. Only the Great Salt Lake in northwest Utah remains, a small remnant of the much larger Lake Bonneville of glacial times.

A mass of ice the size of even a small glacier acts like a viscous fluid. Molasses, for example, will pile up on a table top as long as you keep pouring it. But once you stop, the

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mound that you may have managed to make in the middle of the table rapidly flattens as the molasses flows out and drips to the floor. The Laurentide ice, and the Cordilleran and Scandinavian ice sheets as well, behaved in a similar way after the last glacial maximum. What apparently happened is that the surface seawater in the northern North Atlantic froze, resembling the Arctic of today, and in the process substantially reduced the supply of moisture to the ice. The ice began thinning out and melting along its leading edge, but its surface remained large because the ice kept flowing outward. Twelve thousand years ago about 70 percent of the water locked up in the ice sheets had returned to the ocean, raising sea level approximately 200 feet, from about 300 to about 100 feet below the present level. The ice front, however, still lingered in southern Wisconsin.

After the ice thinned, it began to retreat, producing a rise in temperature. With the warming, the pack ice on the northern oceanic areas disappeared and the supply of moisture was increased. The residual ice sheets were by that time not only very thin but also topographically depressed. In fact, the great mass of ice that had previously existed over the northern continents had depressed the surface of the land by many hundreds of feet through its own weight. Renewed precipitation from the oceans tended to wash away the residual ice rather than rebuild it to its original dimensions of thickness and area. In the North American midcontinent, this glacial meltdown produced giant floods down the Mississippi Valley and into the Gulf of Mexico. Waning ice, however, lingered in both Canada and Scandinavia until about 7,000 years ago, after which the last residue disappeared and the surface of the ocean rose to its present level.

The 300-foot rise of sea level that occurred between 17,000 and 7,000 years ago brought about an encroachment of water on previously dry areas of the continental shelves of the world. Mastodons once roamed the shelf off eastern North America as far out as 125 miles. It is a safe guess that humans, too, inhabited the now drowned shelves of the world. As seawater began rising, humans and animals had to retreat. On steep shorelines, like those around the Mediterranean, displacement inland was minimal. But where the shelves are broad and the slope is gentle, as off the east coast of North America and around the Gulf of Mexico, displacement inland was widespread.

The ice did not melt at a uniform pace. Scientists from the universities of Rhode Island, Miami, and Cambridge, England, noticed that the fossil shells of marine protozoans in certain sediment layers in deep-sea cores from the Gulf of Mexico were greatly depleted in the heavy oxygen-18 isotope. This indicated that the surface seawater where the shells grew was also depleted. That could only have happened if huge floods of ice meltwater had suddenly invaded the Gulf of Mexico. Using radiocarbon dating, scientists at the University of Miami were able to establish that this event took place about 11,600 years ago.

How big was the flood? The isotopic data, together with hydrological and oceanographic considerations, indicate that it was very large indeed. Considering that the volume of the Laurentide ice sheet at its maximum was equivalent to about 900 cubic miles of water, that three-fourths of it drained into the ocean from the Mississippi Valley during deglaciation, and that deglaciation took about 10,000 years, it is possible to calculate that the average yearly discharge of ice meltwater was about 400 cubic miles. To this amount we must add whatever additional precipitation dropped on the Laurentide icecap and the Mississippi Valley below during each year. If we assume that it was essentially the same as today, 135 cubic miles of water must be added, bringing the total Mississippi discharge during deglaciation to about 500 cubic miles, or almost four times the modern rate.

This was the average yearly discharge between 17,000 and 7,000 years ago. We know, from direct observation, that during a so-called fifty-year flood (a flood so large that it occurs only once in fifty years) the Mississippi can discharge as much as three times its total yearly average, or about 400 cubic miles of water. Applying the same ratio to the period of deglaciation, we estimate that a giant flood may have carried as much as 1,600 cubic miles of water, bringing the yearly total for a flood year to 2,000 cubic miles of water. Worldwide, the corresponding rise of sea level would still be very small (about one inch per year) but if the Cordilleran and Scandinavian ice sheets

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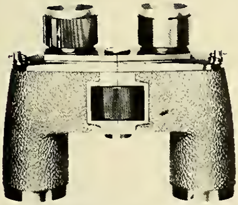

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were melting at comparable rates, sea level rise could have easily been twice as much. On the gently sloping shelves of the world, the sea would have been seen to advance inland 300 feet in a single year or, more appropriately, in a single summer when the snow and ice of winter melt.

At the peak of the last glaciation, Florida was a dry, windswept plateau with such steppelike vegetation as grasses and bushes. Since sea level was 300 feet below the present, one could have walked from Miami over Biscayne Bay to Miami Beach or Key Biscayne, and from there offshore for a mile or two. Then there was a rather steep, rocky slope, and about 300 feet down, a stormy sea would have been seen pounding dead coral reefs. Florida is built largely of porous limestone rock. Because sea level was lower, the water table was also lower, and little water would have been seen on the surface of the peninsula. Rain was immediately absorbed by the ground and found its way to the deep-water table through cracks and fissures, some of which were enlarged to become broad caverns.

In west-central Florida, southeast of Sarasota, there is a circular pond with a diameter of about 260 feet, called Little Salt Spring, that its few visitors thought was a small, tranquil lake. In 1959, an amateur underwater archeologist discovered that the center of the pond had no bottom. Instead, there was a circular opening, some 65 feet across, that gave entrance to a huge underwater chamber. Subsequent explorations showed that the chamber was almost 200 feet deep, was shaped like an inverted funnel, and had a broad circular ledge about seventy-five feet below the opening. These explorations (by Carl Clausen, a prominent underwater archeologist associated with the University of Miami) eventually focused attention on Little Salt Spring.

At the beginning of deglaciation, 17,000 years ago, when sea level stood about 300 feet below the present, Little Salt Spring was a dry cavity about 150 miles from the coast. As ice melted, sea level rose and the water table rose too. When the bottom of the cavern became flooded, Little Salt Spring became an attractive watering hole for nomadic Indian tribes. Twelve thousand years ago, the water level was just below the ledge in the cavern.

Underwater excavations indicate that the ancient Indians used Little

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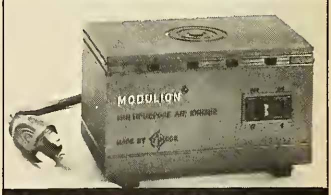

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Salt Spring not only as a source of fresh water, still a rare commodity on the dry limestone plateau, but also as a natural trap for corralling game. A picket fence made of two-foot-long wooden stakes surrounds the opening to the cavern. The stakes may have been used to support branches and thus hide the opening. Game was chased down the steep slope of the basin into the dark water below. There was no possibility of escape. The Indians, lowering themselves from the edge of the cave opening with ropes, would swing onto the ledge and from there capture the helpless animals.

The ledge has yielded bones of an extinct ground sloth, a rabbit, a wood ibis, an extinct bison, and a young mastodon. A giant tortoise shell surrounded by pieces of charcoal was found upside down. An artificially pointed wooden stake, still in place, had been driven through the animal's heart. The tortoise was then cooked on the spot. Only a few square feet of the ledge have been excavated so far, for the extremely dangerous work must be carried out under artificial light in about seventy-five feet of water.

The giant floods of about 12,000 years ago down the Mississippi Valley caused the water table to rise and chased humans off the ledge. Within 2,000 years the water level had risen to the opening at the bottom of the pond. Indians continued to live on the floor of the basin, to build fires and eat deer. Water continued to rise, and in another 1,500 years it reached the present margins of the pond. Because the water table was high, water was abundant on the Florida peninsula and Little Salt Spring was abandoned. Within 500 years, however, or about 8,000 years ago, the water level at Little Salt Spring began falling again and the Indians came back. The basin was once again the site of intense human activity.

The new wave of Indians lived in a village next to the slough, a swampy area adjacent to the pond, and buried their dead—often with branches of aromatic plants and objects and tools of wood, shell, and bone—in the soft muck of the slough and the basin. There are at least 1,000 burial sites at Little Salt Spring.

About 5,200 years ago, the water level begin to rise again, flooding the basin once more. The oxygen-poor environment of the muck in the bottom of the basin and the slough proved

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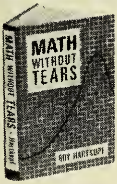

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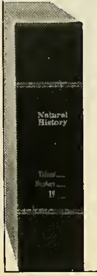

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an excellent preservative of the wooden tools. Hence, Little Salt Spring, once believed to be an insignificant pond among the thousands that dot the Florida plain, has turned out to be a major North American archeological find. Its story is intimately related to deglaciation on the northern continents and the accompanying sea-level change. We hope radiocarbon dating of the sediment covering the cavern ledge will help us pinpoint the rapidity of the rise of sea level that accompanied the great floods down the Mississippi Valley.

Along Bayshore Drive in Miami there is a 125,000-year-old rocky cliff in which the sea long ago carved deep notches. These notches are several feet above the highway. If we take into account the long-lasting sinking of the Florida Peninsula, it turns out that when the notches were formed, sea level was eighteen feet higher than it is today. The most likely explanation for the higher sea level is that some of the ice covering West Antarctica must have melted.

Scientists have estimated that if the ice of West Antarctica, a system of mountain ranges covered with thick glaciers, were to melt today, enough water would be provided to raise sea level about twenty feet. The last time the ice of Antarctica melted, 125,000 years ago, the low-lying coastal areas of the world, including all of south Florida, were flooded. At that time the world was at the peak of an interglacial age, the time between glaciations when world temperature is highest. Today, conditions are exactly the same: isotopic analysis of deep-sea cores shows that world temperature has risen as high as it was 125,000 years ago. But so far, West Antarctica has not melted.

Will it melt before renewed glaciation lowers sea level once more? To answer this question, scientists are now conducting a series of elaborate field observations in and around West Antarctica. The results to date have been rather contradictory. Some say that the West Antarctic ice sheet is unstable and in the process of collapsing; others say that this is not so. Whatever the case, the history of deglaciation of the Laurentide ice sheet and, in particular, its apparent collapse 11,600 years ago, as shown by the giant floods down the Mississippi Valley, may provide us with a glimpse of what could happen if the West Antarctic sheet goes. □

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# Cloudy . . . with a Chance of Rain

## by Gerald Carson

The Rainmakers, by Clark C. Spence. *University of Nebraska Press; $15.95; 181 pp., illus.*

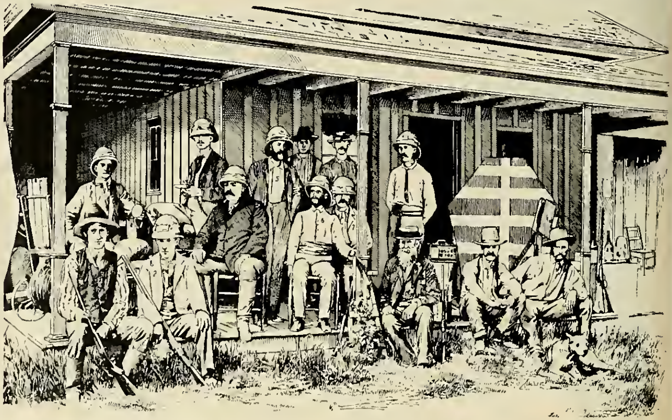
When the merciless sun boils down for weeks on end on the western states that early maps called the Great American Desert; when the corn leaves curl and sicken and even the willows and cottonwoods droop, then farmers and cattlemen scan the sky and anxiously watch the quote board for commodity futures on the Chicago Board of Trade.

Because the desire for rain is primitive and elemental, people, according to their nature and culture, pray, ring church bells, swear, grasp at folkloric theories about precipitation, and extend a credulous welcome to a class of entrepreneurs known as rainmakers. For years Clark C. Spence, a professor of history at the University of Illinois, has made it his scholarly avocation to collect material relating to this bizarre but neglected area of human gullibility. His sources are scattered newspaper and other ephemeral reports, manuscript collections in historical societies, the National Archives, and the U.S. Weather Bureau, and his book is the first full-length treatment of the subject.

The period covered takes notice of some ideas that have come down from antiquity, but extends for the most part from the early years of the nineteenth century down to the time of World War II, when lack of conclusive evidence discouraged the belief in the possibility of forced precipitation. Yet for a century and a half, mystics, spiritualists, flat-earth believers, Bible-text searchers who found in Leviticus 26:4 that they would receive "rain in due season," and outright opportunists all eagerly sought for some method of extracting at will the elusive moisture of the earth's atmosphere. Often they were men with magnetic personalities and an intuitive grasp of popular psychology, skilled in generating spectacular publicity.

A few individuals in good scientific repute advanced theories and claimed successes, men of the caliber of James Pollard Espy (1785–1860), an early meteorologist, and Joseph Henry (1797–1878), physicist and first secretary and director of the Smithsonian Institution, who instituted a system of weather prediction and made original contributions to the knowledge of climatology. Even the granger railroads, with an eye on freight traffic, offered farmers and townsmen suffering from the "drought mentality" financial support and solutions of their own; but they offered above all, hope. The majority of rain "professors" were simply smooth-tongued swindlers, members of the "plug hat" fraternity with a well-honed knowledge of the law of contracts, who employed techniques of persuasion that had been successful in peddling trees and nursery stock, patent gates, lightning rods, vanity books, upright pianos, and medical nostrums.

Professor Spence classifies the rainmakers on the basis of their speculative theories and their motivation. The confidence men were interested in money; the scientists wished to place the study of climatology upon a firmer foundation. Common to all was the belief that artificial means might be invoked to compel the atmosphere surrounding the earth to give up its content of moisture at a time and place chosen by the farmers of the Great Plains or the hydraulic miners of California. Various hypotheses for coaxing rain from reluctant clouds included the possibility of controlling the upward convection of warm, moist air; of jarring showers out of the sky by setting off explosions; of sowing rain clouds with a combi-



*Dyrenforth Rainmaking Expedition,* Scientific American, *January 2, 1892.*

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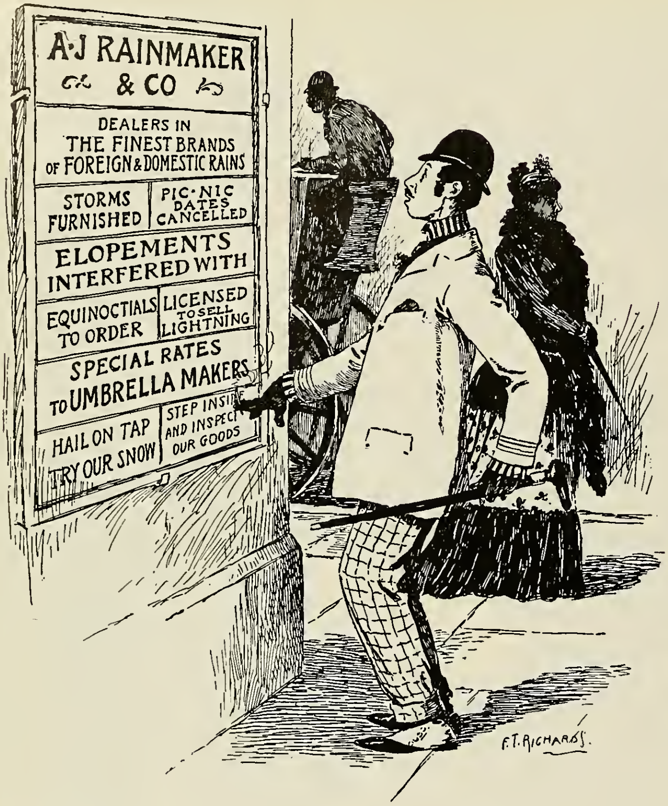

Harper's Weekly, *October 24, 1891*

nation of chemicals, among them liquid ammonia, brine, carbon dioxide, salt, sulfuric acid, and other exotic substances. Since the popular technical wonder of the nineteenth century was electricity, many inventors and theorists attempted to influence the aquiferous cloud cover by taking electricity out of the atmosphere—or putting it in.

Among the empirical notions that surfaced in the shadowy world of "pluviculture," as David Starr Jordan, naturalist, university president, and a skeptic, termed it, was the self-serving belief that plowing and new settlements would increase the rainfall and that steel rails and telegraph wires would also help. In years when rainfall was above normal, optimists declared that the climate was undergoing a permanent change in the direction of heavier precipitation. Down into the twentieth century it was held that rain follows battles, although it was an awkward fact that military campaigns are usually launched in good weather and that it was bound to rain sometime. So artillery fire produced rain: *post hoc, ergo propter hoc.*

Spence discusses in detail many persuasive rainmakers who emerged from obscurity and through studying almanacs and watching the barometer learned how to "make hay" in a dry year. The author conscientiously gives each his due. Two may be mentioned as specimens of the type: Allen Dorman, a Missourian who manufactured a laxative, produced artificial diamonds, published his own poetry, and claimed fifteen rainmaking successes for his Continental Rain-Making Company; and Charles M. Hatfield, self-styled "professor" and former sewing machine salesman, who made a good living out of his secret chemical method and a run of good luck until the drought-stricken thirties washed out the market for his services.

Somewhat higher on the social, or at least the economic, scale were Arthur Brisbane, an important editor and thinker in the William Randolph Hearst publishing empire, who recommended in 1910 that the U.S. government scatter liquid air or perhaps finely powdered lime in the atmosphere, and Charles W. Post, the multimillionaire cereal manufacturer (Postum, Post Toasties, and Grape Nuts). Post had interviewed many Civil War veterans; he believed in the concussion method and fought several "rain battles" in 1911 and 1912 on the Staked Plains of Texas and at Battle Creek, Michigan. Post had no interest in advancing scientific knowledge. He just wanted to prove he could impose his will upon the clouds. The cannonading at Battle Creek was followed by a real gully washer. But as the Weather Bureau pointed out, it rained that same day from the Great Lakes to the Pacific Ocean.

One important topic Spence does not develop is the remarkable absence of any consideration of the consequences of artificial rains. The effects upon vegetation, animal life, and soil erosion are simply ignored. To make this point compelling: How about mosquitos? The effects upon fish populations? And there is a legal thicket in here somewhere. The power to create rain would presumably include the power to withhold or divert it or to cause water to fall upon those who did not want it, such as spectators at athletic events, horse races, or agricultural fairs.

During the years the author has examined, the U.S. Weather Bureau held consistently that the scientific basis was lacking, that all rainmaking experiments were "entirely futile." Today, cloud seeding is being reappraised by the Department of the Interior as part of an enterprise known as Project Skywater. Questions remain touching upon the immensity of the cloud cover sheathing our planet and the effects of rainmaking on biotic communities. Spence has given us a pioneer work, as much about human credulity as climatology. A sequel would be welcome, bringing the story of artificial precipitation down to the decade of the 80s, including—along with the techniques—the legal problems and the environmental impact.

*Gerald Carson, author and social historian, is a frequent contributor to* Natural History *magazine.*

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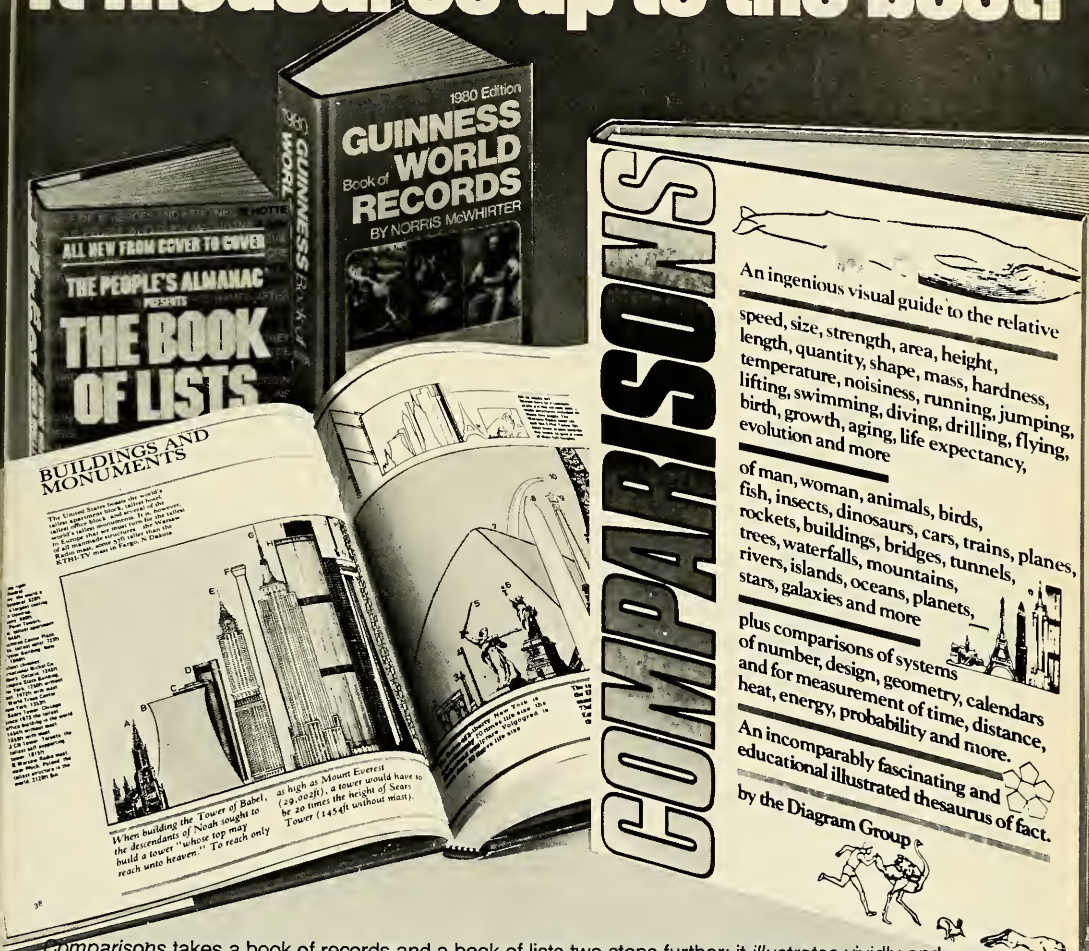
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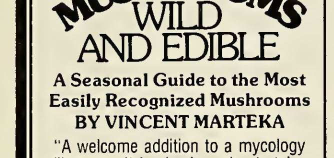

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# Dietary Fiber and Animal Fat

*Differences in nutrition may explain regional patterns in some cancer*

**by Charles D. Gerson**

When we think of medical illness in the developing nations, we think of a long list of exotic and not so exotic diseases. In Europe and America, we are generally thought to be protected from many of the diseases on such a list by our improved sanitation, medical care, and nutrition. Recent reports in the medical literature suggest the opposite—that certain ailments are protected against in Africa and the East but are inadvertently fostered in the West. The main factors at work appear to be nutritional, and one of the anatomical systems most affected is the gastrointestinal tract.

The following story, which illustrates the above paradox, began in eastern Africa, specifically in Uganda. In the early 1960s, several British physicians noted that carcinoma of the colon, or cancer of the large intestine, was distinctly unusual in the Ugandan population. Most notable among those making this observation were Denis Burkitt, a surgeon interested in the incidence and epidemiology of disease in Africa, and Hugh Trowell, who served for many years as a consultant physician at Maherere University in Kampala, the Ugandan capital.

In addition, Burkitt and Trowell noticed that a number of other conditions that were commonplace in England were seldom seen in Uganda. These included diverticulosis of the colon, hemorrhoids, appendicitis, hiatal hernia (a weakness in the diaphragm muscle that separates the esophagus from the stomach), varicose veins, and a constipated bowel pattern. In contrast, in Great Britain and the United States, a gastroenterologist has daily contact with sufferers of these disorders, and in the United States, carcinoma of the colon is the most commonly occurring carcinoma, affecting some 100,000 persons annually.

Many millions of dollars are being spent treating patients with intestinal problems and millions more on cancer research. Burkitt and Trowell realized that Uganda presented an opportunity to deal with preventive measures, always cheaper by far. They were impressed with the effect of geography on disease patterns and felt there must be protective environmental factors at work in Africa. Burkitt was particularly enthusiastic about this idea and his focus was on what Africans are doing that Westerners are not.

There are several dietary differences between the two regions that are obvious to anyone who has ever lived in Africa. The diet there contains much more unprocessed and unrefined fiber, mostly in the form of vegetables. Accompanying this is an increased frequency of daily bowel movements associated with relative softening of the stool. Although not all gastroenterologists agree, many of the Western diseases mentioned above, including diverticulosis of the colon, hemorrhoids, varicosities, and hiatal hernia, could possibly be aggravated by increased pressure within the colon and abdomen, the kind of pressure that may build up in people who are constipated. On this basis, Burkitt formulated the hypothesis that a high fiber diet protected Ugandans from these illnesses by preventing constipation and its associated problems.

This was a provocative idea although subsequent research indicates that it was oversimplified and incomplete. However, like all provocative ideas, it served its main purpose by stimulating epidemiological and biochemical research, mainly in England and the United States. The goal has been to identify the protective elements in societies with a low disease incidence and the injurious elements where the same diseases are common. Whereas Burkitt highlighted the role of fiber as a possible protector, others have emphasized another nutritional difference, namely, that Westerners consume much more animal fat and protein than people in other cultures. In certain illnesses, fiber may be protective; in others, animal fat and protein may be injurious. Over the past decade, research has enabled us to better understand how diet and gastrointestinal disease interrelate.

Before discussing the effects of food fiber on intestinal function, we should understand what scientists and nutritionists mean when they talk about fiber. It is that part of vegetables, fruit, and cereals that resists digestion in the stomach and small intestine and is therefore unavailable as a nutrient source. From the small intestine, fiber enters the large intestine, or colon, where it is either metabolized by bacteria or excreted in the stool.

Most of the fiber of plant cells is found within the cell wall as cellulose, hemicellulose, pectin, and lignin. Part of fiber resides within the cell in the form of mucilages and gums, some of which are natural and some derived from food additives. Most of the substances in the cell wall are polysaccharides, or complex sugars. The main structure of the cell wall fiber is in the form of five-carbon sugars known as pentoses. These sugars have the ability to hold large amounts of water. Within the large intestine, this ability is translated into the creation of a bulk laxative effect and explains many of the attributes of fiber.

The gums and mucilages within the cell, plus the pectin of the cell wall, appear to have different structures and different effects. They consist not only of pentoses but also of hexoses, or six-carbon sugars. The presence of hexoses seems to mitigate against the water-holding ability of this part of dietary fiber. However, the gums, mucilages, and pectin, when given in pure form to humans, have their own particular action. They bind to other foods eaten with them and slow down the exit of food from the stomach to the small intestine. They also bind the bile salts, which are normally secreted by the liver to aid in the absorption of fat, including cholesterol. While these binding effects are not related to the controversy surrounding fiber and lower intestinal disease, there is some experimental evidence suggesting that they may be related to improved control of diabetes and a lowering of blood cholesterol levels.

A number of researchers have been studying the effect of food fiber on the colon. Most of this work has been done using bran, the best and easiest source of food fiber available. However, the societies with high fiber intake generally do not get their fiber from bran or wheat but from vegetables and fruit. In addition, bran appears to have a more dramatic effect on colonic function than other sources of fiber. Nevertheless, some generalizations can be made on the basis of the experiments that have been done with bran.

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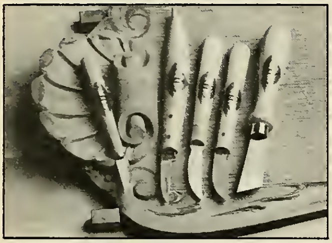

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ity. The total amount of feces passed in twenty-four hours (the fecal volume) and the duration of time it takes for a nonabsorbed substance to pass from mouth to anus (the transit time) are two important measures. There is no doubt that both values are markedly different between Africans and the British or Americans.

In Africa, daily fecal volume is higher and transit time is lower. Lower transit time means a more rapid passage. There is generally an inverse relationship between fecal volume and transit time: the more rapid the transit time, the larger the fecal volume. Since the average African daily fiber intake exceeds three ounces and the average Western intake is less than one ounce, fiber is most likely responsible for the different measurements. This is where experiments with bran are applicable.

Bran was administered, usually in amounts of somewhat less than one ounce per day, to volunteer normal individuals in England by several gastrointestinal research units to see its effect. As expected, persons who ate the supplemental bran had a significant increase in their fecal volume and decrease in its transit time. In one study, concentrated fiber from cabbage, carrot, and apple caused similar but less marked changes. In another experiment, eating bran resulted in a reduction of internal pressure within the large intestine. This information supported the concept that fiber can alter colonic function. But the more interesting question is how fiber relates to colonic disease.

While the idea that fiber intake may be related to hemorrhoids, appendicitis, varicose veins, and hiatal hernia is interesting, it is not based on firm data. The concept that colon cancer may also be related to fiber is quite controversial and will be discussed later. The colonic disease that appears to be most clearly associated with fiber, or rather with a fiber deficient diet, is diverticulosis. A diverticulum of the colon is a small pouch, or pocket, that protrudes from the intestinal canal into the wall of the colon. In diverticulosis, a series of these pouches exists. The pouches alone cause no problem but they can become inflamed, a condition known as diverticulitis, and they can also occasionally cause a hemorrhage.

Fifty years ago diverticulosis was rarely diagnosed in Europe and the United States. Today it is a very common condition. Over 40 percent of people over the age of fifty and 60 percent of people over the age of seventy have diverticulosis. The tendency to develop these pouches increases with age. It also tends to occur in those with a constipated bowel pattern and increased pressure within the colonic canal. Presumably the pressure pushes the colonic wall outward in certain susceptible locations causing the formation of the pouches.

Since diverticulosis is a relatively modern disease associated with constipation and increased intracolonic pressure and since fiber intake appears to have been on the decline during the present century, it seems reasonable to surmise that a fiber-depleted diet may be at least one of the causes of diverticulosis. There is some experimental data that suggest this to be true. The incidence of diverticulosis in a group of British vegetarians with a daily diet of about one and a half ounces of fiber was compared with that in a group of normal age-matched controls who ate less than an ounce of fiber daily. All subjects were over forty-five years old. The vegetarians had a much lower overall percentage of diverticulosis—12 percent compared to 33 percent. Eating bran has also been shown to shorten intestinal transit time and reduce intracolonic pressure in patients with diverticulosis.

The cause of this disease used to be misunderstood, and the former medical custom was to treat patients with diverticulosis with a low fiber diet. The first person to see the way to a more rational approach was a British surgeon named Painter. He advocated the therapeutic use of bran in order to prevent painful attacks and forestall progression of the disease. He did this before all the current knowledge was available and should be credited with bucking the traditional approach.

Painter found that a large majority of his patients responded to a dietary treatment of about a half ounce of bran a day. While there was often an adjustment period when abdominal distension and gas were common, most patients had relief of abdominal pain and constipation. Now that we understand what bran does to colonic pressure and function, Painter's approach has gained general acceptance by other physicians.

Of all the diseases that originally attracted Burkitt's attention in Uganda, carcinoma of the colon is the most important. Because it is the most frequently diagnosed cancer in the United States, learning its cause commands a high priority. The infrequency of its diagnosis in East Africa led to questions about its worldwide distribution that have involved epidemiologists, biochemists, and bacteriologists.

One way to evaluate geographical influences on disease is to compare various possible causative factors with disease frequency in different populations. Carcinoma of the colon occurs with much lower frequency among the peoples of Africa, Asia, and South America than among the peoples of Canada, the United States, Great Britain, and northern Europe, with eastern Europeans somewhere in between. While fiber intake in African countries clearly exceeds that in Great Britain and the United States, there are many inconsistencies in the relationship between fiber intake and colon cancer in other countries so that the worldwide correlation is insignificant.

Studies of the relationship between chronic constipation and colon cancer also show no significant association and cast further doubt on the hypothesis that fiber ingestion protects against colon carcinoma. There is no experimental evidence in animal studies with carcinogens that fiber is protective. Detailed reports about colon cancer among Japanese also fail to establish dietary fiber as a possible preventive agent. In Japan, the disease has a very low incidence, but this rises markedly among Japanese who migrate to Hawaii, both among Issei (first generation) and more so among Nisei (subsequent generation) Japanese. This rise occurs without any significant decrease in fiber intake or increase in intestinal transit time.

All of this information suggests that a search be made for a causative component in the Western diet for colon cancer, and there is abundant evidence implicating animal fat as the culprit. In Africa, in addition to high fiber intake, the diet contains a relative paucity of animal fat and protein. In contrast, Western consumption of animal meat is substantial. The number of hamburgers consumed by Americans is fast approaching infinity. If one examines the correlation between colon cancer and animal fat and protein ingestion on an international basis, it is highly significant. An increase in beef consumption paralleled the increase in colon carcinoma among the Japanese in Hawaii.

Two English bacteriologists have provided bacteriological and biochemical evidence that has broadened our understanding of what eating animal fat may do to the large intestine. They collected a series of stool specimens from Uganda, India, Japan, the United States, and Great Britain and measured them for bacteria, cholesterol (derived from animal fat), and bile salts (secreted by the liver when fat is eaten). A number of differences were apparent between the countries with high and those with low colon cancer rates.

The stools of high-risk populations had higher anaerobic bacterial counts, more cholesterol, and more bile salts. The anaerobic bacteria are particularly adept at metabolizing cholesterol and bile salts and, accordingly, their metabolites were also present. Subsequent studies show that the bacteria in high risk populations have a number of other abilities, some of which could conceivably be applied to precarcinogens, converting them to carcinogens. Whether cholesterol or bile salts or their metabolites can act as a carcinogen or cocarcinogen is entirely speculative at this time.

However, additional evidence suggesting the animal fat–colon cancer connection has come from an epidemiologist and a biochemist working in New York City. They compared cholesterol and bile salt excretion among Japanese and Americans and confirmed the British findings. They have also compared excretory patterns in normal Americans, Americans with colon·cancer, and Americans with colonic polyps, considered to be a premalignant condition. Patients with cancer and those with polyps had cholesterol, bile salts, and their metabolites present in much higher amounts than did the controls.

Our understanding of disease causation progresses slowly and unevenly. We sometimes have to fill in one part of a puzzle while leaving certain voids elsewhere. The story presented here is not complete, but it provides an example of what can result from applying a sound research approach to epidemiological observations. Clearly, the improved nutrition of the Western world has some hazards and requires this type of critical evaluation.

*Charles D. Gerson, a gastroenterologist engaged in practice and research at Mount Sinai Hospital in New York City, has worked in West Africa.*

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# Additional Reading

**Bogs** (p. 48)

*The Bog People: Iron-Age Man Preserved* (Ithaca: Cornell University Press, 1975), by P.V. Glob, translated from the Danish by R. Bruce-Mitford, brings together information about many of the bodies found in bogs throughout northwestern Europe and contains many photographs of them. Glob concludes that many of the bog people may have been sacrificed as offerings to the gods or immolated for the good of the community; others were accident or murder victims. Written by botanists P.D. Moore and D.J. Bellamy, *Peatlands* (London: Elek Scientific Books, 1974) surveys the research being done throughout the world into aspects of mire and peat production. It discusses the ecology and hydrology of peat systems and the use of peat as an energy source, and includes an extensive bibliography. A classic in the field of Irish studies and a thorough review of Irish geography, T.W. Freeman's *Ireland, A General and Regional Geography* (4th ed. New York: Barnes & Noble, 1972), includes information on the different types of Irish bogs. *Irish Heritage* (Dundalk: Dundalgan Press, 1942), written and illustrated by historian-geographer E.E. Evans, devotes a comprehensive, profusely illustrated chapter to bogs. A useful summation of the area's ecology, replete with many photographs, maps, and diagrams, F.F. Darling's *Natural History in the Highlands and Islands* (London: Collins, 1967), contains a chapter on the formation and ecological cycles of bogs.

**Red Fox** (p. 60)

*The Wild Canids: Their Systematics, Behavioral Ecology, and Evolution* (New York: Van Nostrand Reinhold, 1975), edited by M.W. Fox with a foreword by K. Lorenz, is a thorough, illustrated, and indexed review of canid biology. Discussions of the red fox's behavioral ecology in Britain and America, its status in the United States, and its genetics and physiology are among the volume's several interesting articles on red foxes. M. Bekoff and M.C. Wells's "The Social Ecology of Coyotes" (*Scientific American,* April 1980, pp. 130–48) covers the way coyotes, a canid species closely related to the fox, interact with one another and with their environment. This ecological overview explores how the coyote's social organization is a reflection of food resources and the specific behavioral adaptations coyotes seem to make to different food supplies. How coyotes locate and kill prey, the effects of coyote predation, and how the species has adapted to pressures exerted by the environment are also discussed. "Comparisons of Canid and Felid Social Systems from an Evolutionary Perspective" by D.G. Kleiman and J.F. Eisenberg (*Animal Behaviour*, vol. 21, 1973, pp. 637–59), is an in-depth comparison of these two carnivore families. D.W. Macdonald's *Vulpina* (London: Collins, 1977), is an entertaining, accurate children's book about red foxes.

**Wind Architecture** (p. 70)

*Science and Civilisation in China,* volume 4, part II (Cambridge: Cambridge University Press, 1965), by J. Needham with the research assistance of Wang Ling, reviews in detail the origin of the windmill. In his architectural and socioeconomic study *Architecture for the Poor* (Chicago: Chicago University Press, 1973), Egyptian architect H. Fathy describes his approach to extensive reconstruction of housing for the Egyptian rural poor, using materials easily available, such as mud brick, sand, and straw. Fathy discusses forms of Egyptian architecture designed to benefit from climate, including wind catches and screens. "Bastakia Wind-Tower House" (*Architectural Review*, July 1975, pp. 51–53), is a report by P. Jackson and A. Coles on how industrialization threatens Bastakia, the old merchant quarter of Dubai, an area rich in traditional wind architecture. M.N. Bahadori analyzes the sophisticated Iranian wind tower in "Passive Cooling Systems in Iranian Architecture" (*Scientific American,* February 1978, pp. 144–54). Charts detail how different cooling systems use the natural environment to take advantage of Iran's wide range of temperatures. Drawing on examples of indigenous architecture, J.M. Fitch, in *American Building, The Environmental Forces That Shape It* (Boston: Houghton Mifflin Co., 1972), calls for a synthesis between advanced environmentalist theory and everyday architectural design and urges a link between modern architecture and climate.

**Ice Sheets** (p. 82)

For general background on the ice ages, readers should consult J. Imbrie and K.P. Imbrie's *Ice Ages* (Short Hills: Enslow Publishers, 1977), an explanation of the discovery and origin of the ice ages that includes an extensive discussion of temperature changes. R.F. Flint's classic *Glacial Geology and the Pleistocene Epoch* (New York: John Wiley and Sons, Inc., 1947) is a summary of the Pleistocene epoch meant for both geologists and the general reader interested in prehistory. Flint began *Glacial and Pleistocene Geology* (New York: John Wiley and Sons, Inc., 1957) as a revision of his 1947 text, but it evolved into a different book with more up-to-date treatment of some subjects, such as sea-floor stratigraphy and frozen-ground phenomena. C. Emiliani's "Climatic Record in Sediments," an article in the marine sediments section of the *Mc-Graw Hill Encyclopedia of Science and Technology* (vol. 8, New York: Mc-Graw Hill, Inc., 1971), analyzes the temperature record of certain undisturbed Caribbean and Pacific deep-sea cores. In "The Great Flood" (*Sea Frontiers*, September–October 1976, pp. 258–79), he writes about oxygen isotope analysis of sediments as a method of discovering past temperature oscillations, and about the world's largest ice sheet, much of which drained through the Mississippi Valley into the Gulf of Mexico.

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# Celestial Events

### by Thomas D. Nicholson

**The Moon** A waning crescent in the morning sky during the first week, the moon becomes new on November 7, and the early crescent should appear in the evening sky by the 10th. First-quarter moon is on November 15, full moon on the 22nd and last-quarter on the 29th. The moon is new again on December 7, and first-quarter is on the 14th. Apogee moon (farthest from the earth) is on November 5 and December 2, perigee (nearest the earth) on November 20.

**Stars and Planets** The evening sky is almost devoid of bright planets this month. The morning sky is something else again. Venus, Jupiter, and Saturn are putting on quite a show, and Mercury joins them late in the month during an exceptionally good morning elongation. Look for the planets in the east at dawn on any morning. If you watch them regularly, you will see their continually changing relationships with the nearby bright stars Arcturus and Spica and with the crescent moon during the first week of November and December.

The sun is among the stars of Libra for most of November. It passes briefly through Scorpius and into Ophiucus before the end of the month. Mercury starts the month in Libra, moves backward (retrograde) into Virgo briefly at mid-month, and then back into Libra where it remains into December. Venus spends all but the last few days of November in Virgo, moving into Libra before December. Mars moves from Ophiucus into Sagittarius, Jupiter and Saturn are in Virgo, Uranus is in Libra, Neptune in Ophiucus, and Pluto in Bootes.

November 1: The star exceptionally close to the moon this morning is Regulus, in Leo. Observers in states along the Canadian border and in Alaska and Canada can see the moon cover Regulus (an occultation) from about 4:30 to 6:00 A.M., EST.

November 1–3: Watch the eastern sky each morning at dawn to see brilliant Venus move between Jupiter (the higher) and Saturn.

November 3: The Taurid meteor shower (about fifteen per hour) is at maximum.

November 3–4: Be sure to see the late crescent moon pass Jupiter, Saturn, and Venus in the dawn sky. The view on the morning of the 4th will be exceptional.

November 11: Mercury ends its retrograde movement and begins to shift east through the stars again.

November 16–17: The famous Leonid meteor shower reaches maximum.

November 19: Mercury is at its greatest distance to the sun's right, a very favorable elongation. Look for it any morning for another week, in the east after dawn, halfway between Venus and the horizon. Saturn and Jupiter (the brighter) are close together above Venus, and the star to Venus's right is Spica.

November 22: The full moon passes exceptionally close to Aldebaran, the bright star of Taurus, at about 5:00 P.M., EST, and separates slowly to the left of Aldebaran after they rise.

December 13–14: The Geminid meteor shower produces up to fifty per hour after midnight.

**Evening Star Map** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those in the sky. When you face in the other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match the stars in the sky with those on the lower half of the map. The map represents the evening sky at about 11 to 12 P.M. on November 1; 10 to 11 P.M. on November 15; 9 to 10 P.M. on November 30; and 8 to 9 P.M. on December 15. It shows only planets and moon phases above the horizon at those times.

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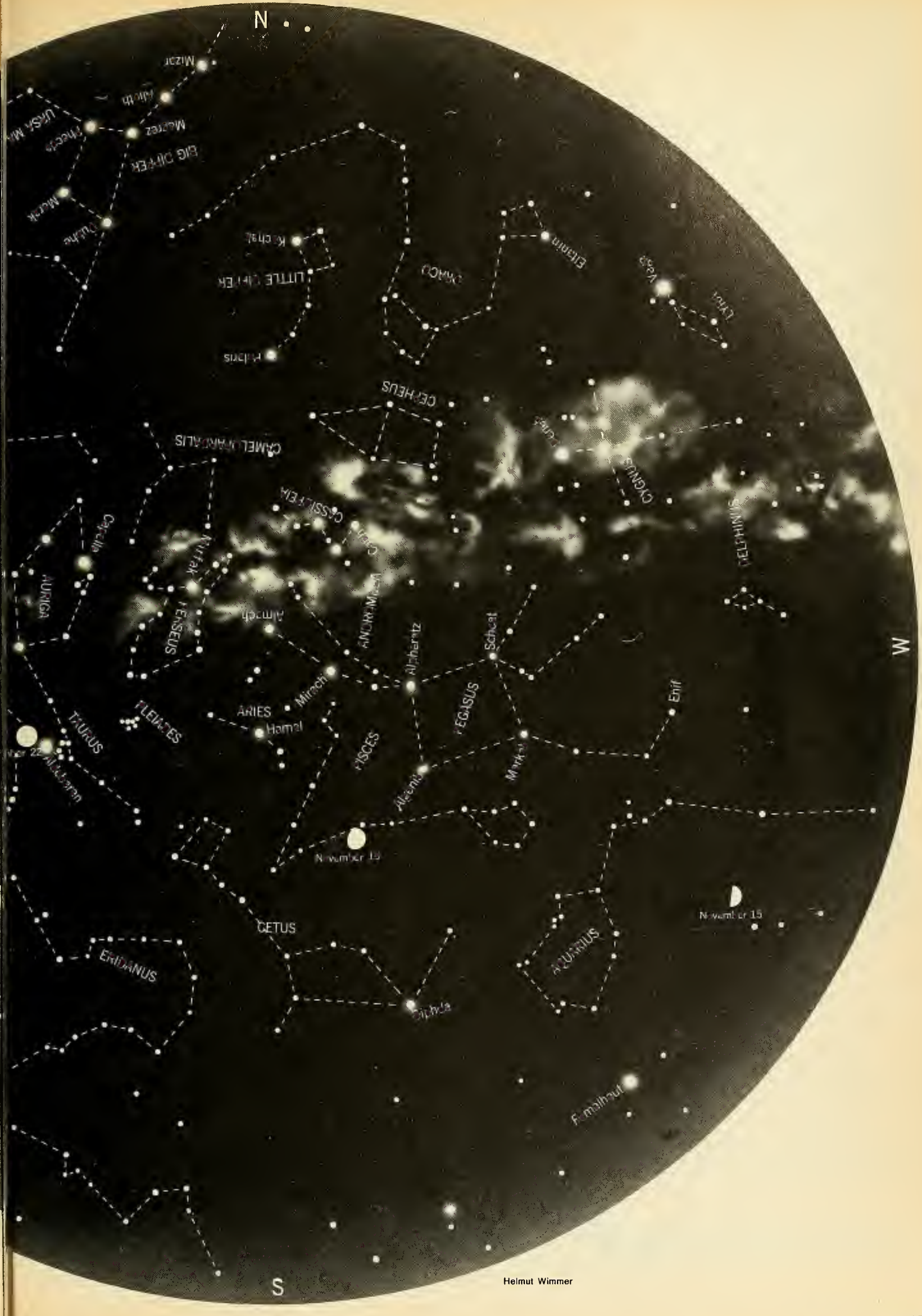
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# The Gamma Ray Mystery

*A possible source of this intense radiation has been identified*

**by Stephen P. Maran**

On about 100 occasions since mid-1967, space instruments have detected strong bursts of gamma rays. The sensitive apparatus currently available reveals that the bursts arrive near the earth about once every three weeks. Until last year, we had no definite information on where the radiation originates, but astronomers have now finally found one source of the mysterious bursts.

The pinpointing of a gamma ray burst was made possible when an exceptionally intense and rapid burst was recorded by nine different satellites and interplanetary space probes of the United States, the Soviet Union, and the Federal Republic of Germany. This event occurred on March 5, 1979.

Gamma rays are a very energetic form of light, with wavelengths shorter than X-rays. They are invisible to the naked eye. Indeed, cosmic gamma rays must be observed from high-altitude balloons or from space since they cannot penetrate all of the earth's atmosphere to reach the ground.

There is a general background of gamma rays that arrive at the earth from all directions at a steady rate, and there also are several known localized, nonbursting sources of the rays, such as the Crab Nebula. However, when a gamma ray burst occurs in a bright flash that often lasts only a few seconds, it briefly outshines all the other incoming gamma rays from the rest of the universe as seen from the earth.

Although not recognized at the time, the first known gamma ray burst was recorded by the U.S. satellites *Vela 4A* and *Vela 4B* on July 2, 1967. These and other satellites of the *Vela* series circle the earth in huge orbits, about 150,000 miles in diameter. From their distant vantage points, the *Velas*—each of which bears an array of sensors to measure gamma rays and other forms of radiation—can detect nuclear weapons blasts occurring above ground on the earth. Supposedly, they could even detect a nuclear bomb set off on the far side of the moon, although this capability has fortunately never had to be put to the test. Intended to monitor international compliance with the Limited Test Ban Treaty of 1963, the satellites provided unexpected dividends through the discovery and subsequent observations of the celestial gamma ray bursts.

In 1972, Ray Klebesadel, a physicist at the Los Alamos Scientific Laboratory in New Mexico, realized that some of the nonnuclear radiation recorded by *Vela* gamma ray detectors on July 2, 1967, and on later occasions was of a celestial nature. Ever since, astronomers have tried to locate the sources of the gamma ray bursts, and astrophysicists have speculated about the processes that generate them.

Progress was frustratingly slow, with an occasional bad lead, despite the enormous strengths of the bursts. According to a fairly conservative estimate made a few years ago, a typical gamma ray burst involves the release of as much energy in a few seconds as the earth receives from the sun during 20 million years. Luckily, the burst sources are much farther away than the sun.

The above estimate was based on the widely held assumption that the bursts come from within our own Milky Way galaxy. The more distant the source of an observed burst, of course, the greater the true energy of the burst at its point of release. Despite the assumption, however, no star or nebula in the Milky Way has been identified as a source of gamma ray bursts.

The basic problem in locating the bursts is this: We have, for practical purposes, two kinds of gamma ray detectors—omnidirectional (or nearly so) receivers and gamma ray telescopes. The omnidirectional receivers (such as the instruments aboard the *Velas*) respond—as their name implies—about equally well to gamma rays from any direction in space. Thus, they record nearly all the bursts bright enough to trigger their detectors. But by the same token, these receivers have no directional discrimination and hence cannot tell where the bursts

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come from. Gamma ray telescopes *do* have directional discrimination, but they miss bursts that come from places where the telescopes are not looking. Since we do not know where the bursts come from or even when they will occur, the telescopes are not especially useful for studying them.

To locate the burst sources, astronomers have had to resort to analyzing the times at which each satellite records a given burst with an omnidirectional receiver. Since the satellites are at different locations, a burst traveling from its sources at the speed of light arrives at the various spacecraft at different times. Whichever satellite is closest to the source receives the burst first.

Given a few satellites, the general direction of a gamma ray burst source, defining a localized patch of the sky, can be determined. But it often turns out that two different sky patches are identified by this procedure; one is as likely to contain the source of a particular burst as is the other. Until the March 5, 1979, burst, the eighty-seventh observed since 1967, no sky area found in this manner was sufficiently small to warrant definitive observations with a large optical telescope, and no specific star or nebula was recognized as a gamma ray burst source.

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By 1979, however, an "interplanetary gamma ray burst network" had been established, consisting of ten satellites and space probes. Of these, five were in orbit around the earth, one in orbit around Venus, and four were located in interplanetary space. The two network craft that were farthest apart were so widely separated that a ray of light would take more than ten minutes to travel from one vehicle to the other. The scientists responsible for operating the network included physicists at Los Alamos and at space research laboratories in Toulouse, Moscow, and Munich and at the Goddard Space Flight Center in Greenbelt, Maryland, and the University of Maryland in College Park.

In the interval since Klebesadel's discovery, theorists, who at first had proposed very disparate origins for the gamma ray bursts, had almost come to agree that the bursts must originate from neutron stars in the Milky Way; that is, from the tiny, extremely dense, and probably highly magnetized collapsed cores of ancient exploded stars—supernovae.

The most famous neutron star is the pulsar in the Crab Nebula, one of only two of the more than three hundred known neutron stars that can be detected in visible light (as opposed to radio waves or X-rays). The purported gamma ray burst-producing neutron stars are presumably likewise invisible and old enough so that (unlike the Crab pulsar) their surrounding nebulae, produced in the supernovae explosions, would have dissipated into space long ago. Further, not all neutron stars need be radio pulsars or X-ray sources. Thus, even if satellites had measured accurate positions for the gamma ray burst sources, astronomers would not have been very surprised if they found nothing at those locations.

It was thus with considerable interest that I learned last year that the strong burst of last March 5 had come from the direction of the Large Magellanic Cloud, a satellite galaxy of the Milky Way, about 150,000 light-years from the earth. If the March 5 burst (which as observed from the earth was a factor of ten stronger than any previously measured burst) had truly come from that galaxy, then it must have been produced by an event at least 100,000 times more energetic than the previously mentioned estimate of a typical gamma ray burst. For a fraction of a second, the burst must have been as powerful as a quasar.

I first learned this news in a phone conversation with Thomas Cline, a physicist colleague at the Goddard Space Flight Center who is a leader of the interplanetary network scientists. Remarkable as the report was, even more exciting information was yet to come. After a more detailed analysis of the data from the many satellites was completed, the search area was narrowed to a small box on the Large Magellanic Cloud. The box was occupied by a little remarked supernova remnant in that galaxy, known as N49.

Neutron stars form in supernova explosions and gamma ray bursts are thought to come from neutron stars. Thus you might expect astronomers to be pleased by the identification of the March 5, 1979, gamma ray burst with a supernova remnant that, we might reasonably infer, contains a neutron star. However, several different teams of scientists, including some experts on gamma ray bursts, have written papers challenging the discovery.

The dissenting scientists insist that the burst must have come, not from the Large Magellanic Cloud, but from a neutron star somewhere in the foreground, that is, near us in the Milky Way. They argue that it is only coincidence that the March 5 burst came from the direction of N49. And they point out that if so powerful a burst came from a star in the Large Magellanic Cloud, many such bursts should come from stars in our own much larger galaxy, and would appear even stronger to us. Yet, as measured from the earth, the March 5 burst was the most intense ever recorded. As a final point, they claim that a burst as energetic as the one in question must have been (if it came from 150,000 light-years away) simply cannot be generated.

Nevertheless, at least one theory has been proposed that apparently *can* explain the great energy of the gamma ray burst from the Large Magellanic Cloud. The radiation, it is asserted, came from the mutual annihilation of electrons and positrons, tiny particles of matter and antimatter, respectively. The spectrum of the gamma ray burst seems to support this theory. This technical debate seems to me, however, to turn on sophisticated concepts of physics while avoiding the real issue, which is, Do we accept the scientific method or merely pay it lip service?

For cogent astrophysical reasons, the prediction was made that neutron stars would prove to be the sources of the gamma ray bursts. Now we have found that a specific burst can be traced in the direction of a supernova remnant, the likely home of a neutron star. In my view the evidence compels us to consider this prediction at least provisionally confirmed even if we cannot explain the findings. It may make more sense to discard some speculations and calculations than to quarrel with the combined observations of nine separate satellites. Facts, often surprising, are surely more reliable than the products of scientists' imaginations.

*Stephen P. Maran is senior staff scientist in the Laboratory for Astronomy and Solar Physics at NASA's Goddard Space Flight Center in Greenbelt, Maryland.*

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# Fossil Surgery

Like the rest of us, scientists at the American Museum of Natural History and elsewhere are fallible. Occasionally their mistakes go beyond the dense pages of an abstruse scientific journal and end up on display.

A year ago, curators at Pittsburgh's Carnegie Museum removed the head of their *Brontosaurus* skeleton, which after a long debate they had concluded belonged to another animal, and replaced it with a more delicate skull. The *Brontosaurus* in the American Museum, now subject to capital verdict, will also lose its head as soon as preparators can fix up a good copy of the new Carnegie skull.

*Brontosaurus* lost its head, but *Elasmosaurus*, a huge, long-necked marine reptile, suffered a worse fate. The first paleontologist to describe it placed its head on its tail, prompting a rival colleague to comment dryly that the new creature should have been named *Streptosaurus* ("twisted reptile").

The American Museum's brontosaurus had formed the basis for brontosaurus reconstructions elsewhere, including the Carnegie Museum's. Similarly, the first complete mammoth skeleton, which was mounted in Saint Petersburg, Russia, more than 200 years ago, was the granddaddy of subsequent reconstructions for nearly 150 years. For some unaccountable reason, the original skeleton was mounted with the tusks reversed, so they curved outward and backward, in flagrant contradiction to the arrangement we observe in elephants today. One hundred and fifty years later, Charles R. Knight, an American Museum artist, spotted the twisted tusks in a photograph and set the Russians straight.

Visitors to the Museum can observe the overactive imagination of several early Museum scientists in the fossil jaw of a great white shark, *Carcharodon megalodon*. This creature cruised the early Miocene seas, feeding on bony fishes and warmblooded marine mammals. The largest shark that ever lived, it looked almost exactly like the dreaded great white of today, only bigger.

With a length of forty-three feet and a weight of possibly nine tons, this particular fellow needed no help from Museum scientists to look impressive. Nevertheless, the paleontologists who reconstructed its jaw in 1909 made it nearly twice the size it should have been. They picked the biggest teeth they could find in the Museum's collection, even though a shark's teeth diminish greatly in size toward the back of the jaw. On top of that, they built plaster jawbones that were oversized even in proportion to the big teeth. The result was a maw of truly chimerical dimensions, six feet high and nine feet across. After completing their work, the six proud paleontologists stood inside the gaping jaw for a formal picture. Awed by their own creation, they estimated the creature must have been eighty feet long.

For some time the Museum has known the jaw is inaccurate. Now, John Maisey, a new curator in the Department of Vertebrate Paleontology, wants to do something about it. "The public," he says, "isn't going to like it, but the jaw will have to come down by a third at least. How could such an inaccurate reconstruction have been made if scientists were using live *Carcharodon* jaws for comparison? They let their enthusiasm run away with them."

Maisey, an expert on sharks, continued: "The fossil *Carcharodon* was a first-rate predator. Its descendant, the great white shark, is even warmblooded, which is essential for an active predator."

He turned over a palm-sized fossil tooth in his hand. "Its teeth were supremely adapted to biting and cutting. Scientists performed an experiment in which they shoved an aluminum-and-steel rod down a dead herring and fed it to an eight-foot bull shark. From the tooth dents in the rod they calculated its biting force at 40,000

**Poison-Dart Frogs and Other Friends**

Scientists from the Museum's Department of Herpetology will show live snakes, frogs, toads, lizards, and turtles on *Amphibian and Reptile Day*, Sunday, November 23, from noon to 4:00 P.M. in Gallery 3. They will also bring out mounted and preserved specimens from the collection and talk about the Museum's fieldwork and research in herpetology. *Amphibian and Reptile Day* is free for members, $3.00 for nonmembers.

**Tibet and China**

On the weekend of November 8 and 9, from 2:00 to 4:00 P.M. in the Auditorium, three films on the Himalayas will be shown. Included is C.S. Cutting's 1935 film *Beyond the Forbidden Frontier*, the first footage of life in Tibet. On November 15 and 16, three 1980 films on the People's Republic of China will look at life in three cities: X'ian, Suzhou, and Beijing (Peking). The films are free.

**Asia Live**

The People Center is presenting weekend programs that include dance, music, crafts, and traditional cooking from various regions of Asia: on November 1 and 2, Japan; November 8 and 9, the Himalayas; November 15 and 16, and 22 and 23, China; November 29 and 30, the Near East. All programs are free and run from 1:00 to 4:30 P.M.

**Mount St. Helens**

The Exhibit of the Month is a film that shows some of the recent eruptions of Mount St. Helens and other volcanoes. The film, which runs continuously in the Roosevelt Rotunda, discusses volcanoes and their causes.

**Time and the River**

An exhibition on the geology of the Grand Canyon and Bryce and Zion canyons is on display in Gallery 77. *Profiles of the Past: The Geology of Three Southwest Canyons* explores the geologic history of the Southwest as revealed by the canyons' rock walls. It includes photographs of the canyons, rock samples, geologic maps, and fossils.

**Dance and Music from the East**

Two programs of Asian dance and music will be presented in the Auditorium. On Sunday, November 2 at 2:00 P.M., Japanese dancer Saeko Ichinohe and her pounds per square inch. And *Carcharodon*, remember, was five times bigger than the bull shark.

"These sharks probably went through 10,000 teeth in a lifetime and swallowed many of their own teeth while feeding. They were always teething, which I imagine made them awfully cross."

Various people have posed for pictures inside the fossil jaw, including the staff of the present-day Vertebrate Paleontology Department. As publicity for the movie *Jaws*, Peter Benchley was filmed sitting inside the jaw with a lamp, table, and chair. Unfortunately, if the jaw is remodeled, it may no longer accommodate human beings.

Just as *Brontosaurus* was recently decapitated by the heartless progress of science, so, too, may *Carcharodon* suffer radical orthodontic alterations. Undoubtedly, as new discoveries are made, other reconstructed skeletons in the Museum's collections will undergo drastic surgery.

company will perform modern dances inspired by Japanese dance tradition. On Wednesday, November 5, at 7:00 P.M., the Chinese Music Ensemble of New York will present an evening of traditional Chinese music and some modern Chinese compositions. Beginning two hours before each performance, free tickets will be distributed on a first-come, first-served basis at the first floor Information Desk.

**Prizewinners**

The winning photographs of the 1980 Natural History Photographic Competition are on display in the Center Gallery.

**Scrutinizing Crowds**

The November Members' program will be a lecture by William H. Whyte on his ten-year study of urban spaces. Whyte, author of *The Social Life of Urban Spaces* and "Street Life" (*Natural History*, August 1980), will use slides and film to illustrate how people use New York's streets, plazas, and parks. This program is free for members, $3.50 for non-members, and will be presented in the Auditorium on Wednesday, November 12, at 7:30 P.M.

*Douglas J. Preston*

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# The Independence Fair

*Midwestern county fairs are a tribute to the traditions of American rural life*

**by Raymond Sokolov**

"As American as apple pie," we say, meaning that this apparently simple dessert is a symbol of the nation. But there is nothing at all simple about either the country or the pie. Needless to say, America has changed radically since early settlers brought their recipes for apple pie with them from Europe. And like all immigrants to these shores, apple pie took on a new nature in the New World. It became our preeminent national dish because in the isolated, primitive farmhouses of colonial America, apple pie was much more than a dessert. Ideally suited to the rugged climate and the low technology of the farms where most settlers lived, the apple pie was a basic means of survival: appetizer, entree, and dessert at winter meal after winter meal in the dawn of the Republic.

On the Ulster County, New York, farm he worked after the Revolution, Michel Guillaume Jean de Crèvecoeur harvested 100 apple trees for his own use, something he would not have done in his native France, and felt obliged to explain when he wrote about his life in a series of letters aimed at an urban European audience:

> Perhaps you may want to know what it is we want to do with so many apples. . . . In the fall of the year we dry great quantities, and this is one of the rural occupations which most amply reward us. Our method is this: we gather the best kind. The neighboring women are invited to spend the evening at our house. A basket of apples is given to each of them, which they peel, quarter, and core. . . . The quantity I have thus peeled is commonly twenty bushels, which gives me about three of dried ones.
>
> Next day a great stage is erected either in our grass plots or anywhere else where cattle can't come. Strong crotches are planted in the ground. Poles are horizontally fixed on these, and boards laid close together. . . . When the scaffold is thus erected, the apples are thinly spread over it. They are soon covered with all the bees and wasps and sucking flies of the neighborhood. This accelerates the operation of drying. Now and then they are turned. At night they are covered with blankets. If it is likely to rain, they are gathered and brought into the house. This is repeated until they are perfectly dry.

Processed in this way, Crèvecoeur's apples would last through the winter—a staple food source that required only an overnight soaking in warm water to be ready for the oven. Apples were at the very center of this pioneer farmer's diet. He wrote: "My wife's and my supper half of the year consists of apple-pie and milk."

Today, two centuries later in our history, no farmer sustains his family on apple pie suppers all winter long. And even if he did, a farmer is no longer typical of American life, for there are too few of them. But farmers are still the guardians of symbolic values and practices sacred to the nation's sense of itself. They are uniquely equipped to continue and preserve our traditions, particularly our food customs, in pristine form because almost without exception, American food customs arose in farmhouses as adaptations to rural conditions. And so, to check on the health of our edible traditions, one goes to the heartland. Since Crèvecoeur's day, the geographical center of American farm life has moved westward, and the best place to observe the ritual of apple pie at its zenith is at a Midwestern county fair with a serious apple pie contest.

Practically the first thing I saw after arriving at the Buchanan County Fair in eastern Iowa was a black bull galloping free as you please in a rampaging circle that ran from the cattle stalls to the livestock judging arena, around to the midway, past the 4-H exhibit hall, and then back to the pickup that had brought him, not fully broken, from the farm. He made several snorting circuits, once or twice dragging a man who grabbed his trailing halter, but causing no harm to him or anyone else except to the Band Boosters, who had to repitch one corner of their tent, which the bull had grazed, before they could resume selling bandburgers (sloppy Joes) and homemade apple pie and ice cream to raise money for the Independence High School band.

Independence, Iowa, is the seat of Buchanan County and the site of its annual fair, a showpiece of old-fashioned agricultural vigor held in the baking heat of late July when the hay is mostly in and the corn and soybeans are not yet ready to harvest. Similar fairs are staged all over the country during this relatively slow time for farmers, each one an individual expression of the quality of rural life in a single county.

The Buchanan fair is no more typical of the status quo of American agricultural life than any other. Indeed, the town of Independence, although small, with fewer than 6,000 inhabitants, has a definite urban feel to it, stemming partly from its proximity to industrial Waterloo, twenty-three miles to the west, and partly from

otographs by Adelaide de Menil

*A rampaging bull is captured before he causes too much damage.*

its past as a milling center and the Midwest's harness-racing capital. Today, however, the beautiful brick Wapsipinicon Mill stands empty, a casualty of gigantism in the grain trade, and all that remains of the Rush Park racetrack is the show barn, restored and converted into a restaurant. Yet from my room at the Rush Park Motel, which is still within the city limits, I could see fields and smell the unmistakable smell of hogs.

Independence is, above all else, the center of a region that, while practicing modern agriculture with its overwhelming emphasis on machines, has managed to hold on to at least some of its human, cultural traditions. People still have the upper hand in Buchanan County. You can see it at the fairgrounds, which gives space to the collection of the county historical society—antique farm tools, an old-time kitchen, and an early blacksmith shop—but does not, as so many fairs do, have displays of hulking tractors and other modern machinery hauled in by salesmen from John Deere and Massey-Ferguson.

During fair week at Independence you can learn something about traditional farm life—and the vanishing species of farm families who still live it—by driving just a short way out of town on the perfectly perpendicular network of crushed limestone roads that link the spacious fields of corn and soybeans springing up in some of the world's richest topsoil. In this immense grid of unparalleled fecundity, a road that cuts across the others on a diagonal is a landmark. And it is shortly after you have turned off at such an oblique intersection that you arrive at the Priebe family's farm.

Meeting the Priebes takes a minute or two, since the whole clan, assembled for dinner, includes Clifford and Wilma Priebe; their married daughter Bonnie, her husband Mike O'Brien, and their little daughter, Marie; 21-year-old Stan Priebe, who will some day take over the farm's several hundred acres; teen-age live wire Cindy; and two children of grade-school age, Celia and Dale.

When the assembled Priebes sit down to dinner (they would call it supper; "dinner" means lunch in the Corn Belt), they eat almost no food they do not produce themselves. The day I visited, the extremely tasty pork roast came from one of their many hogs; this one had been butchered at a local abattoir called a "locker." The sweet corn on the cob was picked fresh and although not quite ripe enough to satisfy the Priebes' refined expectations, it still surpassed most corn that finds its way to Manhattan retailers. The cabbage for Wilma Priebe's tart slaw came from her large kitchen garden. And there were mashed potatoes and fruit jello and a pitcher of creamy raw milk coaxed by hand from the family milch cow. Dessert was, of course, apple pie, with a crust flaky from lard and a tart filling of early Harvester apples picked from a nearby tree and made elegant with cream (see recipe below). As a menu, the meal was mundane, except for the sheer number of vegetable side dishes. But the freshness of the ingredients and the skill of the cook raised it to a high level. At the Priebes' table, one finds mainline American cookery at its best, the food of the farmhouse, splendid there, close to the soil. But when exported in cans or in the recipe files of Midwestern dieticians to institutional dining rooms or to the pages of women's magazines,

FARMERS OF AMERICA
*Three young men display carefully groomed sheep for judging.*

Wilma Pr

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*Wilma Priebe and her daughters preparing their prizewinning apple pies.*

this perilously simple cuisine almost invariably becomes second-rate and insipid.

No doubt Wilma Priebe could make a first-class apple pie from supermarket apples in a city apartment kitchen, but the right context can be important for a cook, and it goes a long way toward enhancing the taste of food. Certainly it would be hard to imagine a better context for appreciating pork roast and apple pie with a lard crust than a farmhouse where hogs get loose during supper and little Dale runs out to shoo them back to their pen.

The Priebes, without intending it, are big on context. Unlike many successful Midwestern farmers, they have not eliminated livestock and confined their operation to profitable, relatively undemanding grains. Pork and beef and broiler chickens all prosper on their land. There is a bull called Delbert, a pet mule, and a goat whose milk is used to feed the pet raccoon.

The pet raccoon is not as tame as Cindy Priebe would like it to be, but she hasn't had the time to work with it properly because, she says, she's been too busy with 4-H work. Her club has been emphasizing sewing. The club also puts her in touch with neighbor girls she might not otherwise see too often since she attends a parochial high school in town. Through 4-H camp counseling and other statewide events, she has acquired contacts throughout Iowa, while her brother Stan visited a big farm in Mount Upton, New York, on a 4-H exchange.

On a national scale, 4-H (for head, heart, hands, health) has five million schoolchildren as members; only 25 percent of them, however, live on working farms. Administered under the Department of Agriculture's Cooperative Extension program, 4-H is no longer a supplementary education service reserved for farm kids. There is even a 4-H program in New York County, New York (Manhattan). With the dramatic exodus from farms after World War II, 4-H has moved into nonrural areas because that is where the children are. But in a rural county such as Buchanan, 4-H still functions in the old way and reaches its culmination at the annual fair.

All the livestock shown at the Buchanan County fair is exhibited by 4-H members. Parents may help with the elaborate grooming of the animals, but their children have spent hours and hours working with the cattle and sheep and hogs, feeding them to produce a prize shape and training them to behave properly for the judges.

A 4-H sponsored garden contest was won in 1980 by Sandy Oliphant, who managed to cultivate staked tomatoes, purple beans (they turn green when cooked, but their purple color makes them easy to locate for picking), Concord grapes, black raspberries, zucchini, purple kohlrabi, cabbage, broccoli, cauliflower, acorn squash, pumpkin, bell peppers, cucumbers, and a patch of carrots left unthinned to show children with thumbs less green why thinning is necessary for producing big carrots.

There are 4-H sponsored competitions in almost every imaginable area from house plants to geology to photography, including a "self-determined" class for the recognition of unclassified achievement. The 1980 self-determined winner was a scrapbook compiled over several years by Rachelle Reid, who adopted wild burros from the federal government and recorded the experience in progressively more sophisticated essays written as she and the burros grew older.

In the area of prepared foods, the Buchanan County 4-H conducted judgings in seventeen categories of canned fruit, eleven categories of pickles and relishes, and thirty-three categories of baked goods, ranging from white bread to rhubarb cake. Indeed, the only food event at the fair not sponsored by 4-H is the pie contest, which is run by the Buchanan County Porkettes. Wives of pork producers, the Porkettes volunteer their time to promote the use of pork products. They give food demonstrations with pork in supermarkets. They work with pigskin. And at the fair, under the aegis of Lady Loinette, the nattily skirted and jacketed sow that is their symbol, they superintended the baking of thirty-nine pies. According to official contest rules, every crust had to contain lard, and the contest was judged with meticulous expertise by two home economists and crowned by an auction in the fair's livestock show ring. Local bankers and seed merchants bid hot and heavy, spending $60 and more to get a pie and some good PR in the bargain.

Virtue was rewarded. Wilma Priebe won the blue ribbon in the adult division. Her daughter Cindy took the junior division championship. Their crusts flaked; their fillings fulfilled every criterion of excellence. In one county in Iowa, at least, people are keeping the American heritage in apple pie order.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

**Wilma Priebe's Grand Champion Apple Pie**
Buchanan County Fair, Independence, Iowa, 1980

*Crust*

3 cups flour
1 teaspoon salt
1 cup (8 ounces) lard
1 tablespoon vinegar
5 tablespoons water (or milk for golden crust)
1 egg

1. Mix flour, salt, and lard together in a bowl, cutting in the lard with a pastry blender until you produce a crumbly texture like that of uncooked oatmeal.
2. In another bowl, mix vinegar, water (or milk), and egg with a rotary beater. Then blend into the flour-lard mixture a little at a time. Blend well.
3. Divide dough into four equal pieces, enough for two double-crusted, 9-inch pies. This dough rolls easily and will take a lot of handling and still make a flaky crust. Refrigerate or freeze until needed.

*Filling*

3½ cups peeled, cored, and sliced tart cooking apples
1 cup sugar
2 tablespoons flour
1 teaspoon vanilla
⅔ cup half-and-half

1. Combine all ingredients in a bowl and mix together thoroughly. This is enough filling for one 9-inch pie.

*Final Assembly and Baking*

1. Preheat oven to 450 degrees
2. Roll out one of the balls of dough into a circle about one-eighth inch thick. Dust the work surface lightly with flour before you start. Use more flour as necessary to prevent sticking. When you have a circle of dough large enough to fill and slightly overlap the edge of a 9-inch pie pan, transfer the crust to the ungreased pie pan. Trim off excess. Crimp along the edge with tines of a fork or your finger, pressing dough to the flange of the pan.
3. Place apple filling in the pie pan, spreading it evenly over the dough.
4. Roll out another ball of dough as above. Moisten the edge of the bottom crust with a small amount of water. Place the top crust over the pie. Press around the edges. Slash through the crust in a few places or make a small hole in the center.
5. Bake 10 minutes. Then reduce oven temperature to 350 degrees and bake another 30 to 40 minutes, until crust is nicely browned and the apples feel tender when probed with a trussing needle through the top crust. Cool on a rack.

Yield: One 9-inch double-crusted pie, plus dough for a second double-crusted pie

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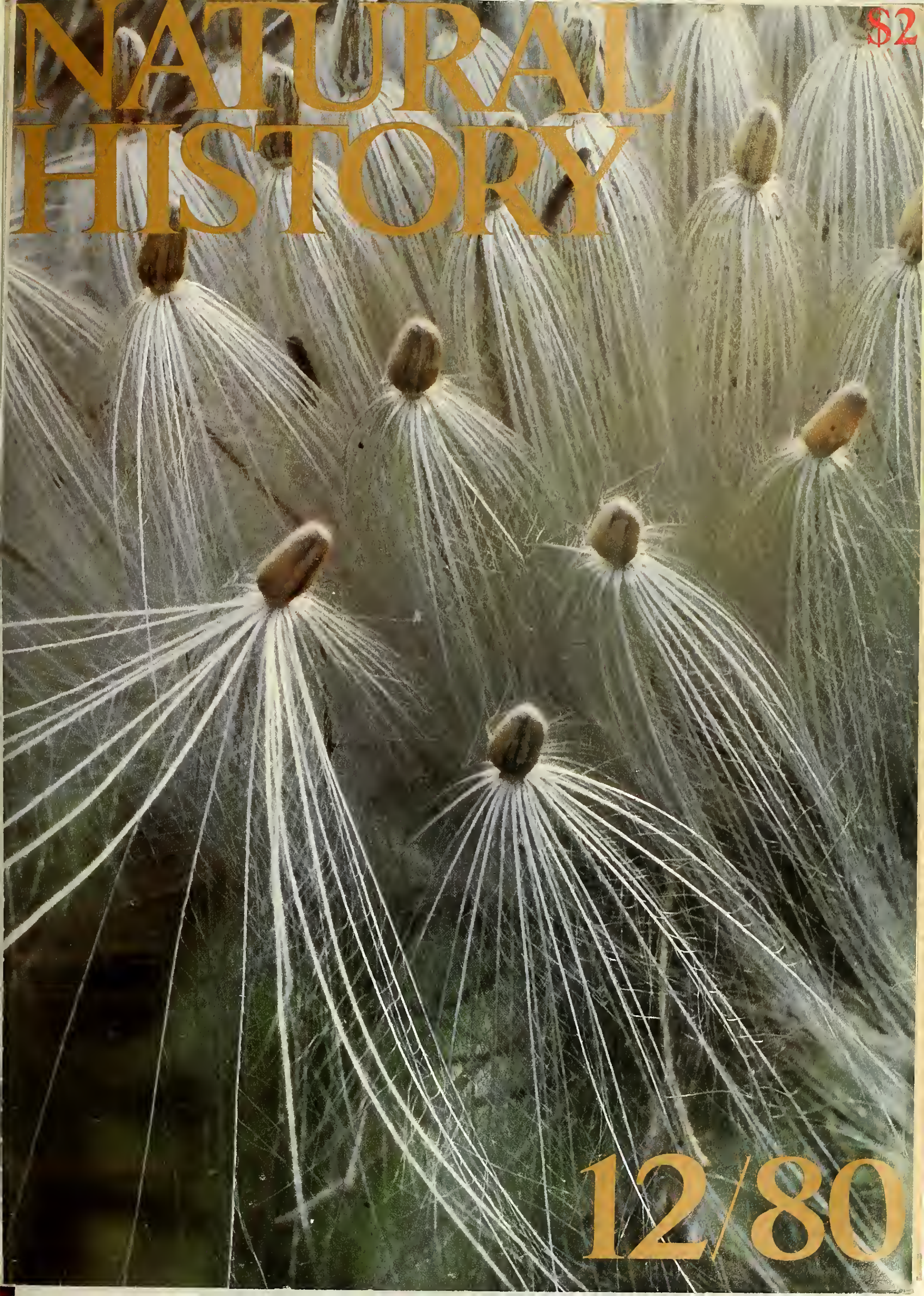

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**A Note to Readers:** The American Museum of Natural History has increased the number of issues of *Natural History* from 10 to 12 a year. Every subscription was extended to include the additional copies at no cost to the member. At the same time, the Museum discontinued its separate bonuses. But members will receive bonuses in issues, such as the calendar-poster in this issue. We plan to include another in the June issue for the subsequent six months.

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**Jack M. Kugelmass** learned of the mostly poor and elderly Jews who live and worship in New York City's forbidding South Bronx from Yoav Levy, the photographer on the story. The two are currently putting together a book on this subject. Researching the article out in the streets was a change of pace for Kugelmass, who had recently received his Ph.D. from the New School for Social Research. His anthropology dissertation on the Jews of prewar Poland was based on published memoirs found in libraries. Kugelmass conducts seminars on the ethnography of East European Jewry at the Max Weinreich Center for Advanced Jewish Studies at the YIVO Institute in New York City. An avid cyclist, he has been studying urban bicycle messengers—as a participant-observer.

An enthusiastic birder and overall student of natural history, **John Kricher** first became interested in the nature of weeds while doing research on the diversity of bird species in a recently abandoned field. He subsequently received his Ph.D. from Rutgers University and is currently associate professor of biology at Wheaton College in Norton, Massachusetts. His present research topics include an analysis of range expansion of several passerine bird species in New England and studies of ecosystem perturbation in relation to chemical compounds. Kricher lives with his wife and a pet collared peccary, which impresses him "both with its intelligence and its ability to thrive in the New England winter."

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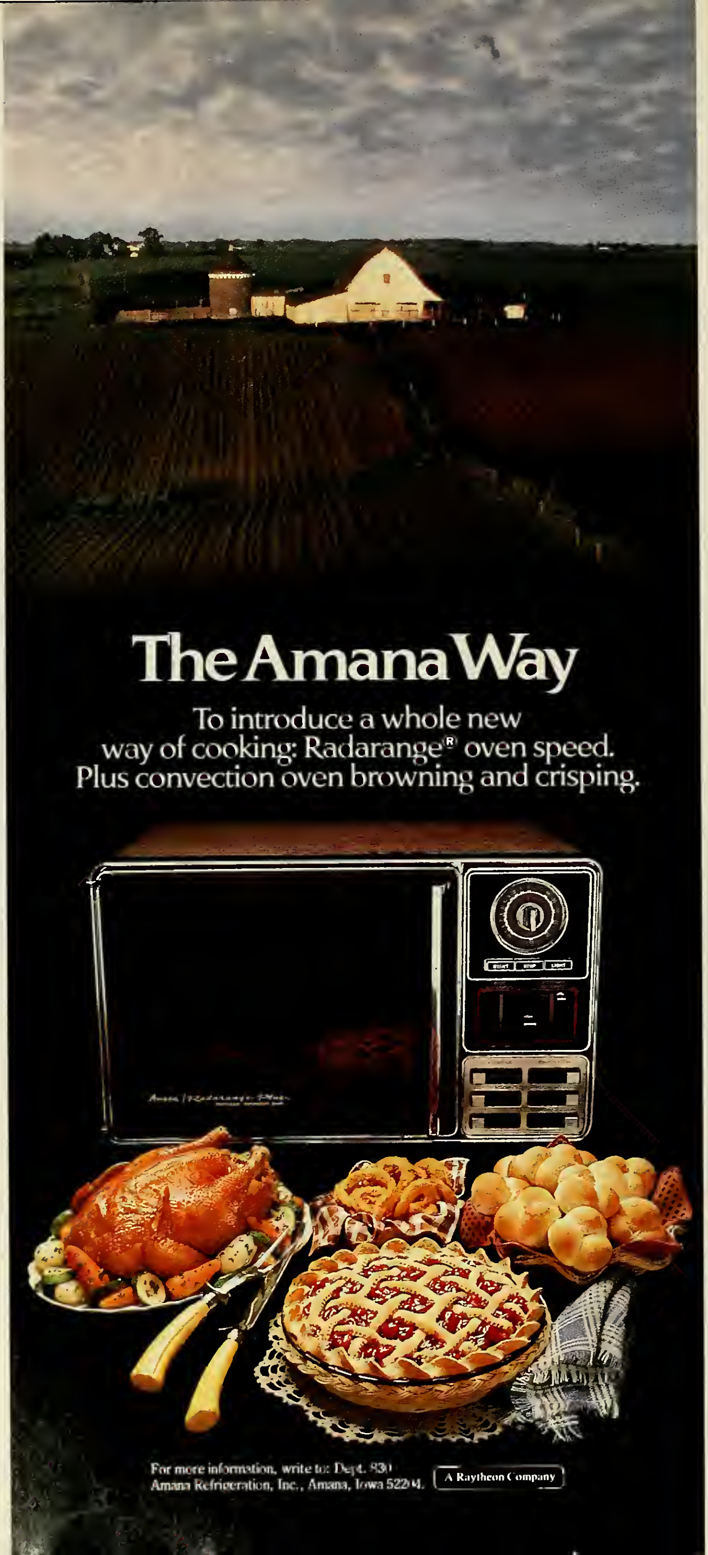
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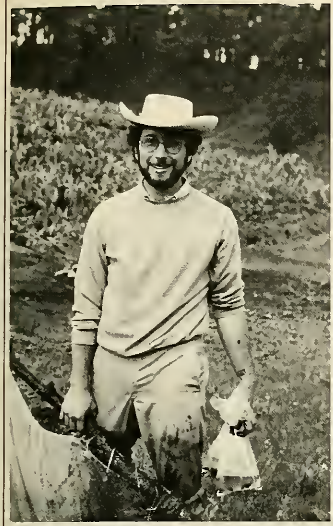
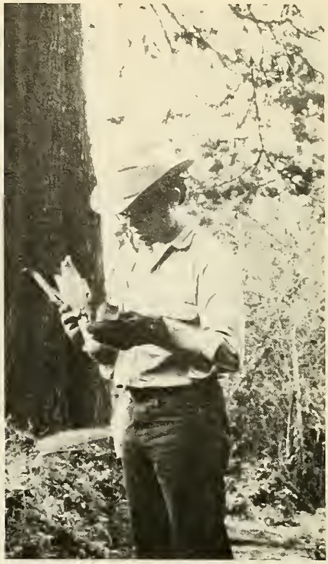
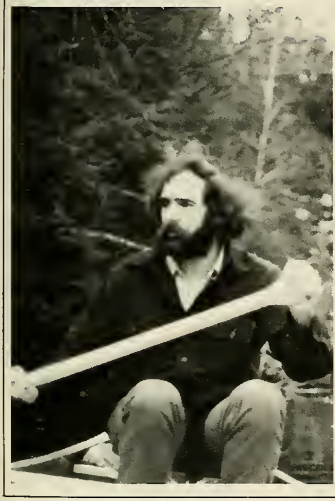


A spare-time jazz singer, **James Hanken** recently received his Ph.D. in zoology from the University of California at Berkeley. He is now on his way to Dalhousie University in Halifax, Nova Scotia, where he will serve as a Killam Postdoctoral Fellow, and continue his research on miniaturization in vertebrates, particularly salamanders. Hanken is also a semiprofessional photographer, having had his work published in several books and magazines and winning a first prize in the *Natural History* photographic competition of 1979.

The ecology and evolutionary biology of plethodontid salamanders in North and Central America has been a strong interest of **James F. Lynch.** A research biologist at the Smithsonian Institution, Lynch has also pursued fieldwork on the community ecology of ants and the island ecology of birds that inhabit patches of forest in eastern North America.



**David B. Wake** is a professor of zoology and director of the Museum of Vertebrate Zoology at the University of California, Berkeley. His work has emphasized the evolution of adaptive morphology. He has studied salamanders since his first year in graduate school, an interest that developed into investigating the systematics of plethodontid salamanders, using comparative morphometric, osteological, allozymic, developmental, and immunological approaches.



Physicist **Michael Oppenheimer** is affiliated with the Harvard-Smithsonian Center for Astrophysics and lectures on astronomy at Harvard University. While doing research on the composition of comet gas he became intrigued with the history of comets and that, in turn, led to the article in this issue. Oppenheimer got a bachelor's degree in chemistry from MIT and a Ph.D. in chemical physics from the University of Chicago. He has written for *Natural History* before (see "What are Comets Made of?" March 1978, page 42). Coauthor **Leonie Haimson** is a recent Radcliffe College graduate in social studies who has launched a career as a freelance writer. Among other work, she has written an as-yet-unpublished book on hysteria among women in nineteenth-century America.

# Nutrition and Brain Development

*Malnutrition early in life can cause developmental abnormalities within the brain, but these negative effects can often be reversed by proper nutrition and exposure to an enriched environment*

### by Myron Winick

During the late 1950s and early 1960s there was a great deal of concern about the possibility that malnutrition during very early life might result in permanently retarded mental development. Studies from South Africa, Mexico, Chile, and other places suggested that children hospitalized during infancy for malnutrition had reduced I.Q. scores and poor academic performance when they reached school age. In a world in which 300 million children were estimated to have suffered significant malnutrition in infancy, this presented a potential problem of enormous magnitude.

At the same time, other studies clearly showed that early malnutrition profoundly retarded physical growth and markedly curtailed the expected increase in head circumference. Hence the implications were that the body was not reaching expected height and that the brain was not reaching expected size.

Experiments quickly undertaken in animals confirmed the observations in human populations and extended them by showing that animals undernourished during the nursing period had reduced brain sizes, a reduced amount of brain myelin content (the covering sheath of nerve fibers), and a reduced number of brain cells. In addition, the number and complexity of neuronal connections were reduced. Most of these changes were found to be permanent unless rehabilitation began very early in life.

These same experimental animals were shown to exhibit abnormal behavior: they were unable to run a maze properly or to extinguish a learned reflex, and again, this behavior persisted into adult life even if the animals were rehabilitated after their early exposure to malnutrition. Thus a single exposure to severe food restriction during the neonatal period not only impaired brain growth and function but also induced permanent changes in brain structure and in the animals' behavior.

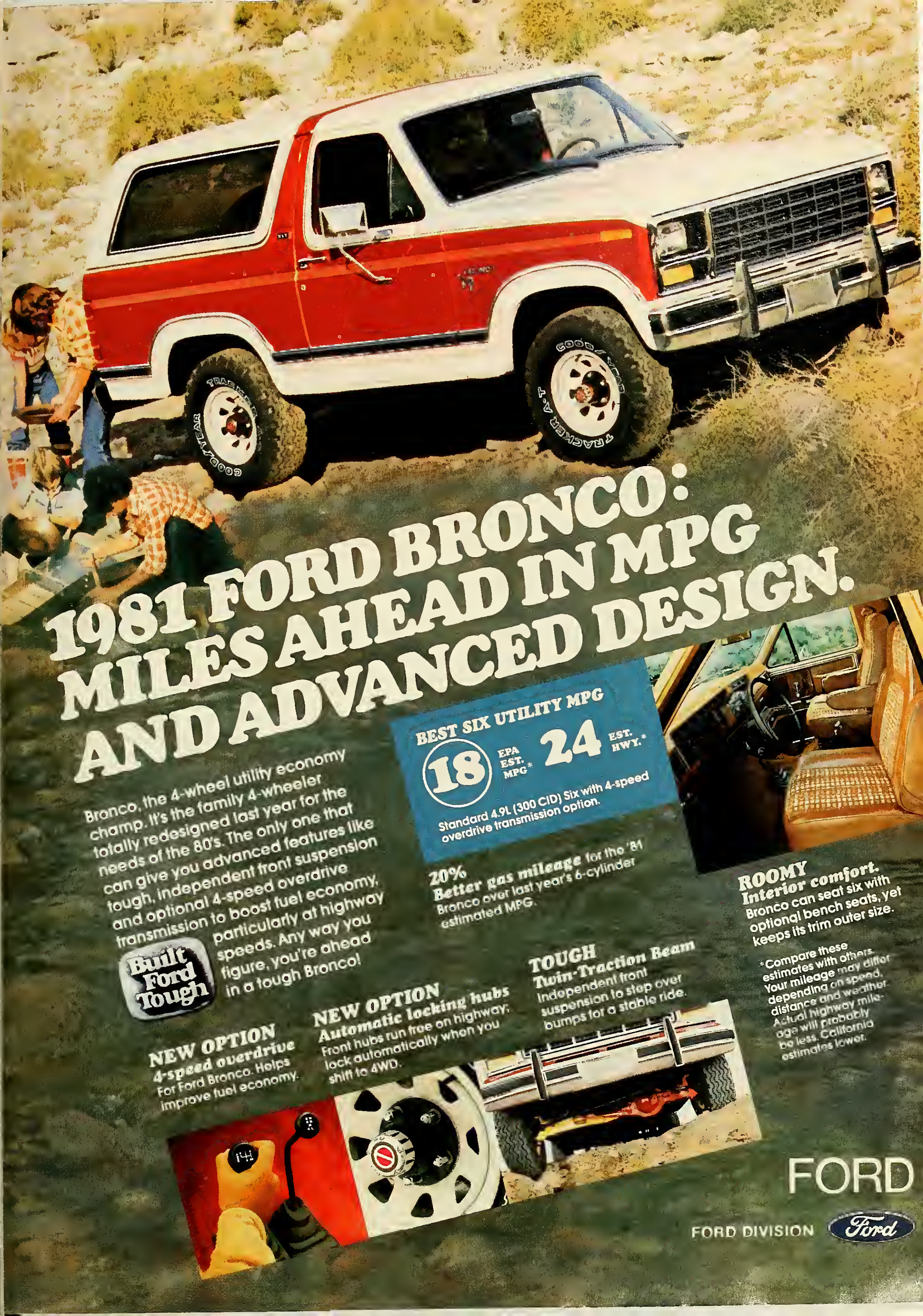
These studies raised obvious questions about human malnutrition, especially as seen in Third World countries. Does malnutrition retard growth and alter the structure of the *human* brain? What is the critical time during which malnutrition must occur in order to cause such changes? Do structural and biochemical changes induced by malnutrition lead in some way to the developmental changes that have been described in children?

Before studies could be undertaken to examine the effects of early malnutrition on the human brain, the normal pattern of cellular growth had to be determined. To do this the brains of children who died in accidents, from accidental poisonings, or from other catastrophic events were examined. By analyzing these brains for DNA content and dividing by the known amount of DNA in any human diploid cell (6.0 millionths of a gram), the number of cells in the human brain at any given time was determined.

The data indicated that the number of human brain cells reached their maximum by about eighteen months of age. Moreover, like the findings in experimental animals, there were three distinct periods of cellular growth in the human brain. The earliest period, occurring before birth, was characterized by a rapid proliferation of cells with little or no increase in their size. The second period, from birth to eighteen months, was characterized by a progressive decrease in cell proliferation and a concomitant increase in cell size. The third period, from eighteen months until beyond three years, was characterized by cell enlargement only, with no further increase in cell number. Additional studies indicated that the increased number of cells during the first period could be divided into an early increase in the number of neurons, peaking at about twenty-six weeks of gestation, and a later increase in the number of glia, or supporting cells, peaking around birth.

Thus human brain growth could be characterized by a progression of cellular events. First the neurons themselves rapidly divide and increase their number, then the glial cells reach maximum rates of cell division, and finally cells begin to enlarge as myelin is deposited and as branches grow and arborize, building the ultimate network of axonal and dendritic connections that characterizes the mature brain.

It was obvious from these studies that if one wanted to study the effect of malnutrition on the cellular development of the human brain, the time when malnutrition occurred was critical. The earlier the malnutrition, the greater the potential for interfering with cell division and ultimately reducing the number of brain cells. In



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the late 1960s and early 1970s a series of studies in Chile established those facts. Brains of children who died of severe malnutrition during the first year of life (infantile marasmus) were examined. The data clearly showed that the number of cells in the brains of these children was reduced from the norm. This reduction was noted in all of the brain regions examined and was of a similar magnitude to the reduction noted in the brains of animals severely malnourished during the neonatal period. In addition, again paralleling the findings in animals, the deposition of myelin and the extent of dendritic arborizations were found to be reduced.

Without question, early malnutrition as it occurred in the Third World was producing cellular and structural changes in the human brain. By correlating the actual brain changes with the head circumferences of those children who died of malnutrition it could be shown that the head circumference was an accurate reflection of the actual brain weight and the number of brain cells. Accordingly, the more severe the cellular damage, the smaller the head circumference.

With millions of children surviving early malnutrition but left with two of its major results—short stature and reduced head circumference—these data again raised the question of the adequacy of brain development in a large segment of the world's children. In addition, these findings, coupled with previous findings that similarly malnourished children who survived showed permanent developmental abnormalities and that the severity of these abnormalities also correlated with the degree of reduction in head circumference, raised the question of a direct association between the structural changes and the functional outcome.

In the early 1970s several studies began to suggest that this view of the effects of early malnutrition was probably an oversimplification. Animal psychologists noted that behavioral abnormalities identical to those exhibited by animals malnourished early in life occurred in animals that were not malnourished but were reared in isolation. Moreover, if the animals were stimulated in a variety of ways, the expected behavioral changes induced by neonatal malnutrition did not occur. The psychologists postulated that there was an interaction between malnutrition and environ-

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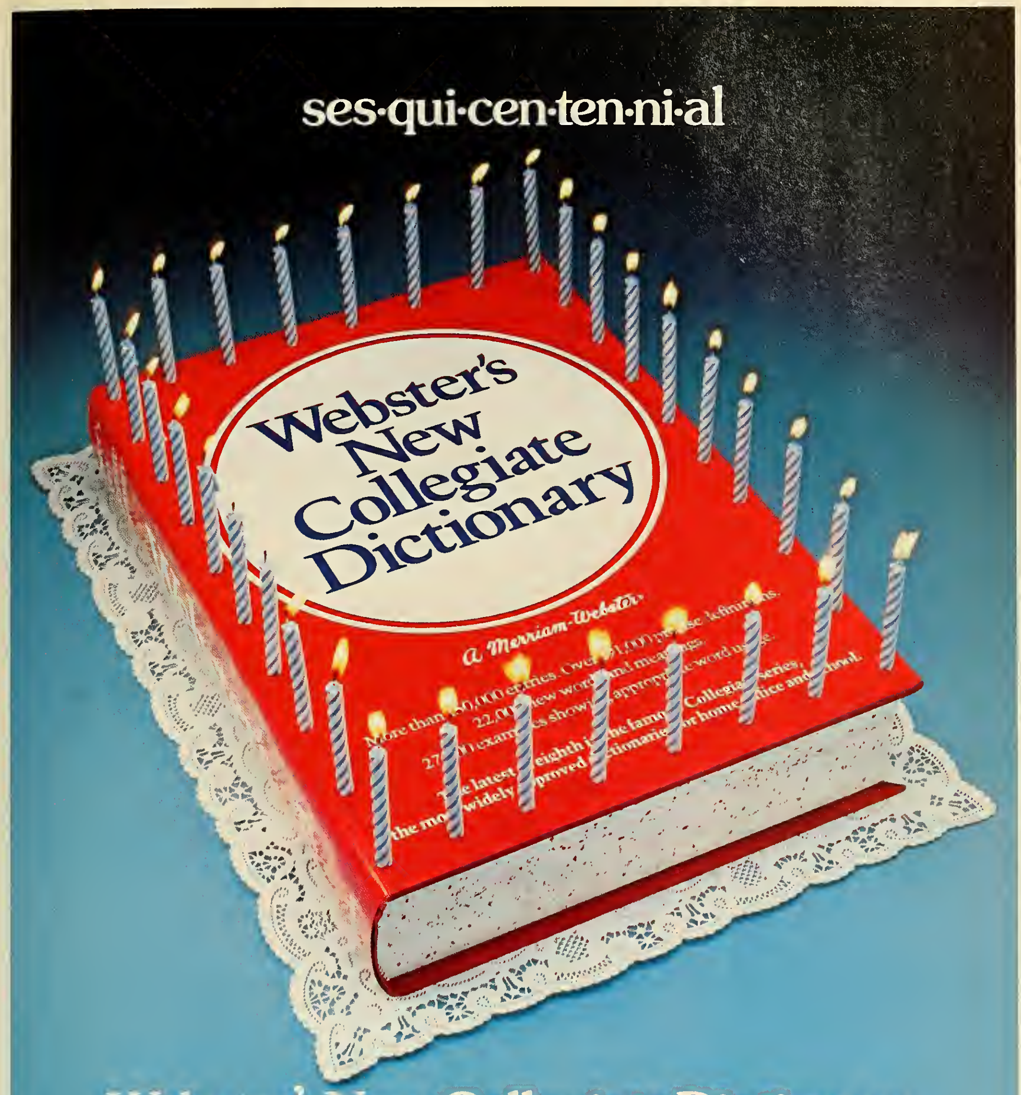
mental deprivation that accounted for the behavioral abnormalities and, further, that early malnutrition may exert its effects on behavior by "functionally isolating" the animal from its environment, thereby preventing the normal stimuli necessary for proper development from reaching the animal at the proper time.

Several observations in human populations suggest that this hypothesis might be correct. First, malnourished children from Third World countries (the populations that had been primarily investigated) invariably grew up in deprived environments. Second, such children were apathetic and often much less demanding than better-nourished children. Hence they were deprived of even the little attention that was available. Third, and perhaps most important, children who were as malnourished as the investigated Third World children, but who came from more enriched environments, did not show the expected deficits in I.Q. or school achievement.

One study examined United States children with cystic fibrosis, a serious medical condition that is invariably associated with severe early malnutrition. By age five these children had normal I.Q.'s and achievements. Another study investigated children with pyloric stenosis, a condition that also results in severe early malnutrition. Again, their I.Q.'s and achievements were normal. Consequently, the data suggested that although malnutrition early in life could directly retard brain growth and alter brain structure, it did not in itself affect mental development. Only when malnutrition was coupled with a deprived environment were the behavioral effects manifested. These observations raised a crucial question. Could malnourished children growing up in an environment of poverty and deprivation develop normally if they were subsequently exposed to an enriched environment?

In an attempt to answer this question, a study was made of a group of Korean orphans severely malnourished in the first year of life but subsequently adopted by middle-class United States families before the age of three. By the time these children reached school age their average I.Q. scores were 102 and they were achieving at the average level for American children. Although they had not quite reached the levels of similarly adopted Korean children who were well nourished during infancy—whose average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I.Q. was 112—they had shown an enormous amount of recovery. All previous studies on malnourished populations of children, reared in the impoverished environments from which they came, showed I.Q. scores in the sixties or low seventies.

A second study, employing the same populations of Korean orphans, but this time examining children who were adopted after the age of three, demonstrated that I.Q. and achievement dropped in both the previously malnourished and previously well-nourished group, and that the children who had been malnourished in early infancy had I.Q.'s and achievement scores below the United States norms. However, even with adoption after three, these children did significantly better than one would expect had they been returned to their previous environment. Hence the anticipated behavioral effects of early malnutrition occurring in a deprived environment seemingly were either prevented or reversed if the child was subsequently reared in an "enriched" environment.

As might be expected, these studies raised questions about children growing up in deprived environments in the United States. Was the same interaction between poor nutrition and environmental deprivation retarding development in certain segments of our own population? Two groups of children were compared. Both groups had been put in foster care but the children in one group had remained in a single foster home until they were studied, whereas those in the second group had lived in several different foster homes during the study period. The assumption was that a single foster home would provide a more stable environment than multiple foster homes. The results bore this out, demonstrating an average I.Q. score fourteen points lower in the group reared in multiple foster homes.

In carrying out further analysis of the data on foster home children, yet another correlation was noted. A strong relationship was found in the multiple foster home group between I.Q. and height. The smaller the child, the lower the I.Q. This correlation did not, however, hold among the single foster home children. Since severe early malnutrition invariably results in short stature and since the only children whose I.Q. and school performance were reduced were those short children reared in the multiple foster home environment, an interaction between early malnutrition and a deprived environment again seems probable.

In sum, the data so far available suggest that malnutrition early in life exerts two somewhat different effects on the brain. The first is retardation in the rate of cell division and curtailment of myelination and dendritic arborization, resulting in cellular, structural, and biochemical abnormalities within the brain. These changes will occur regardless of the child's environment. The second is a series of behavioral changes that occur as a consequence of the interaction of malnutrition with environmental deprivation. Early malnutrition alone will not produce these changes and enriching the environment even after the interaction has taken place may prevent the changes from occurring.

Some final questions currently under study are whether any chemical events in the brain can be altered by this interaction of nutrition and environment and if such alterations do take place, can they explain abnormal behavior. Recent studies in rats have demonstrated that early malnutrition reduces the concentration of n-acetyl neuraminic acid (NANA), one of many chemical substances secreted by the neurons that may affect the transmission of nerve impulses, in the dendritic tips. Environmental stimulation *increases* the concentration of NANA. In addition, injection of NANA into malnourished animals *increases* its concentration at the synapses of the dendrites and prevents the expected behavioral abnormalities. Consequently, it is possible that both early malnutrition and environmental deprivation work through a single final biochemical pathway and that by altering that pathway behavior can be modified.

In the past thirty years we have come full circle. Whereas initially we believed that early malnutrition invariably led to structural and chemical changes in the brain that, in turn, left permanent behavioral scars, the current data suggest that the behavioral changes are caused by a different mechanism and, much more important from a practical standpoint, that the changes are potentially reversible.

*Myron Winick is the director of the Institute of Human Nutrition and a professor of nutrition and of pediatrics at the College of Physicians and Surgeons at Columbia University.*

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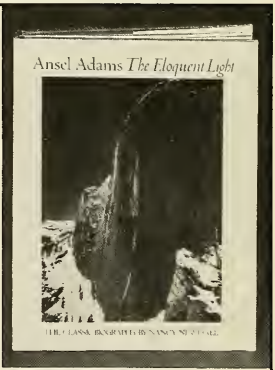

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# Science and Jewish Immigration

*Dubious research became the basis for excluding millions of eastern and southern Europeans*

**by Stephen Jay Gould**

In April, 1925, C.B. Davenport, one of America's leading geneticists, wrote to Madison Grant, author of *The Passing of the Great Race,* and the most notorious American racist of the genteel Yankee tradition: "Our ancestors drove Baptists from Massachusetts Bay into Rhode Island, but we have no place to drive the Jews to." If America had become too full to provide places of insulated storage for undesirables, then they must be kept out. Davenport had written Grant to discuss a pressing political problem of the day: the establishment of quotas for immigration to America.

Jews presented a potential problem to ardent restrictionists. After 1890, the character of American immigration had changed markedly. The congenial Englishmen, Germans, and Scandinavians, who predominated before, had been replaced by hordes of poorer, darker, and more unfamiliar people from southern and eastern Europe. The catalog of national stereotypes proclaimed that all these people—primarily Italians, Greeks, Turks, and Slavs—were innately deficient in both intelligence and morality. Arguments for exclusion could be grounded in the eugenic preservation of a threatened American stock. But Jews presented a dilemma. The same racist catalog attributed a number of undesirable traits to them, including avarice and inability to assimilate, but it did not accuse them of stupidity. If innate dullness was to be the "official" scientific rationale for excluding immigrants from eastern and southern Europe, how could the Jews be kept out?

The most attractive possibility lay in claiming that the old catalog had been too generous and that, contrary to its popular stereotype, Jews were stupid after all. Several "scientific" studies conducted between 1910 and 1930, the heyday of the great immigration debate, reached this devoutly desired conclusion. As examples of distorting facts to match expectations or of blindness to obvious alternatives, they are without parallel. This essay is the story of two famous studies, from different nations and with different impact.

H.H. Goddard was the director of research at the Vineland Institute for Feeble-minded Girls and Boys in New Jersey. He viewed himself as a taxonomist of mental deficiency. He concentrated upon "defectives of high grade" who posed special problems because their status just below the borderline of normality rendered their identification more difficult. He invented the term "moron" (from a Greek word for "foolish") to describe people in this category. He believed at the time, although he changed his mind in 1928, that most morons should be confined to institutions for life, kept happy with tasks apportioned to their ability, and above all, prevented from breeding.

Goddard's general method for identifying morons was simplicity itself. Once you had enough familiarity with the beast, you simply looked at one, asked a few questions, and drew your evident conclusions. If they were dead, you asked questions of the living who knew them. If they were dead, or even fictitious, you just looked. Goddard once attacked the poet Edwin Markham for suggesting that "The Man with the Hoe," inspired by Millet's famous painting of a peasant, "came to his condition as the result of social conditions which held him down and made him like the clods that he turned over." Couldn't Markham see that Millet's man was mentally deficient? "The painting is a perfect picture of an imbecile," Goddard remarked. Goddard thought he had a pretty good eye himself, but the main task of identifying morons must be given to women because nature had endowed the fair sex with superior intuition:

> After a person has had considerable experience in this work, he almost gets a sense of what a feeble-minded person is so that he can tell one afar off. The people who are best at this work, and who I believe should do this work, are women. Women seem to have closer observation than men.

In 1912, Goddard was invited by the U.S. Public Health Service to try his skill at identifying morons among arriving immigrants on Ellis Island. Perhaps they could be screened out and sent back, thus reducing the "menace of the feeble-minded." But this time, Goddard brought a new method to supplement his identifications by sight—the Binet tests of intelligence, later to become (at the hands of Lewis M. Terman of Stanford University), the Stanford-Binet scale, or the conventional measure of IQ. Binet had just died in France and would never witness the distortion of a device for identifying children who needed special help in school into an instrument for labeling people with a permanent stamp of inferiority.

Goddard was so encouraged by the success of his preliminary trials that he raised some money and sent two of his women back to Ellis Island in 1913 for a more thorough study. In

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two and a half months, they tested four major groups: thirty-five Jews, twenty-two Hungarians, fifty Italians, and forty-five Russians. The Binet tests produced an astounding result: 83 percent of the Jews, 87 percent of the Russians, 80 percent of the Hungarians, and 79 percent of the Italians were feeble-minded—that is, below mental age twelve (the upper limit of moronity by Goddard's definition). Goddard himself was a bit embarrassed by his own exaggerated success. Weren't his results too good to be true? Could anyone be made to believe that four-fifths of any nation were morons? Goddard played with the numbers a bit, and got his figures down to 40 or 50 percent, but he was still perturbed.

The Jewish sample attracted his greatest interest for two reasons. First, it might resolve the dilemma of the supposedly intelligent Jew and provide a rationale for keeping this undesirable group out. Second, Goddard felt that he could not be accused of bias for the Jewish sample. The other groups had been tested via interpreters, but he had a Yiddish-speaking psychologist for the Jews.

In retrospect, Goddard's conclusions were far more absurd than even he allowed himself to suspect in anxious moments. It became clear, a few years later, that Goddard had constructed a particularly harsh version of the Binet tests. His scores stood well below the rankings of all other revisions. Fully half the people who scored in the low, but normal, range of the Stanford-Binet scale tested as morons on Goddard's scales.

But the greater absurdity arose from Goddard's extraordinary insensitivity to environmental effects, both long-term and immediate, upon test scores. In his view, the Binet tests measured innate intelligence by definition, since they required no reading or writing and made no explicit reference to particular aspects of specific cultures. Caught in this vicious circle of argument, Goddard became blind to the primary reality that surrounded his women on Ellis Island. The redoubtable Ms. Kite approaches a group of frightened men and women—mostly illiterate, few with any knowledge of English, all just off the boat after a grueling journey in steerage—plucks them from the line and asks them to name as many objects as they can, in their own language, within three minutes. Could their poor performance reflect fear, befuddlement, or physical weakness rather than stupidity? Goddard considered the possibility but rejected it:

> What shall we say of the fact that only 45 percent can give sixty words in three minutes, when normal children of 11 years sometimes give 200 words in that time! It is hard to find an explanation except lack of intelligence. . . . How could a person live even 15 years in any environment without learning hundreds of names of which he could certainly think of 60 in three minutes.

Could their failure to identify the date, or even the year, be attributed to anything other than moronity?

> Must we again conclude that the European peasant of the type that immigrates to America pays no attention to the passage of time? That the drudgery of life is so severe that he cares not whether it is January or July, whether it is 1912 or 1906? Is it possible that the person may be of considerable intelligence and yet, because of the peculiarity of his environment, not have acquired this ordinary bit of knowledge, even though the calendar is not in general use on the continent, or is somewhat complicated as in Russia? If so what an environment it must have been!

Goddard wrestled with the issue of this moronic flood. On the one hand, he could see some benefits:

> They do a great deal of work that no one else will do. . . . There is an immense amount of drudgery to be done, an immense amount of work for which we do not wish to pay enough to secure more intelligent workers. . . . May it be that possibly the moron has his place.

But he feared genetic deterioration even more and eventually rejoiced in the tightening of standards that his program had encouraged. In 1917, he reported with pleasure that deportations for mental deficiency had increased by 350 percent in 1913 and 570 percent in 1914 over the average for five preceding years. Morons could be identified at ports of entry and shipped back, but such an inefficient and expensive procedure could never be instituted as general policy. Would it not be better simply to restrict immigration from nations teeming with morons? Goddard suggested that his conclusions "furnish important considerations for future actions both scientific and social as well as legislative." Within ten years, restriction based upon national quotas had become a reality.

Meanwhile, in England, Karl Pear-

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son had also decided to study the apparent anomaly of Jewish intelligence. Pearson, who had been christened Carl but changed the spelling to proclaim his Marxist allegiance, was an ardent socialist—proving once again that politics is a peculiarly unpredictable business, and that adherents to a philosophy preaching regard for mankind in general need not extend their affection to individual humans in despised groups.

Pearson's study was as ridiculous as Goddard's, but we cannot attribute its errors (as we might, being unreasonably charitable, in Goddard's case) to mathematical naïveté, for Pearson virtually invented the science of statistics. Pearson, the first Galton Professor of Eugenics at University College, London, founded the *Annals of Eugenics* in 1925. He chose to begin its first issue with his study of Jewish immigration, apparently regarding it as a model of sober science and rational social planning. He stated his purpose forthrightly in the opening lines:

> The purport of this memoir is to discuss whether it is desirable in an already crowded country like Great Britain to permit indiscriminate immigration, or, if the conclusion be that it is not, on what grounds discrimination should be based.

If a group generally regarded as intellectually able could be ranked as inferior, then the basic argument for restriction would be greatly enhanced, for who would then defend the groups that everyone considered as stupid? Pearson, however, loudly decried any attempt to attribute motive or prior prejudice to his study. One can only recall Shakespeare's line, "The lady doth protest too much, methinks," when Pearson proclaimed his objectivity so stridently:

> There is only one solution to a problem of this kind, and it lies in the cold light of statistical inquiry. . . . We have no axes to grind, we have no governing body to propitiate by well advertised discoveries; we are paid by nobody to reach results of a given bias. We have no electors, no subscribers to encounter in the market place. We firmly believe that we have no political, no religious and no social prejudices. . . . We rejoice in numbers and figures for their own sake and, subject to human fallibility, collect our data—as all scientists must do—to find out the truth that is in them.

Pearson had invented a statistic so commonly used today that many people probably think it has been available since the dawn of mathematics—the correlation coefficient. This statistic measures the degree of relationship between two features of a set of objects: height versus weight or head circumference versus leg length in a group of humans, for example. Correlation coefficients can range as high as 1.0 (taller people are invariably heavier to the same degree) or as low as 0.0 for no correlation (an increase in height provides no information about weight—a taller person may weigh more, the same, or less, and no prediction can be made from the increase in height alone). Correlation coefficients can also be negative if increase in one variable leads to decrease in the other (if taller people generally weigh less, for example). Pearson's study of Jewish immigration involved the measurement of correlations between a large and motley array of physical and mental characters for children of Jewish immigrants living in London.

Pearson measured everything he imagined might be important in assessing "worthiness." He established four categories for cleanliness of hair: very clean and tidy, clean on the

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whole, dirty and untidy, and matted or verminous. He assessed both inner and outer clothing on a similar scale: clean, a little dirty, dirty, and filthy. He then computed correlation coefficients between all measures and was generally disappointed by the low values obtained. He could not understand, for example, why cleanliness of body and hair correlated only .2615 in boys and .2119 in girls, and mused:

> We should naturally have supposed that cleanliness of body and tidiness of hair would be products of maternal environment and so highly correlated. It is singular that they are not. There may be mothers who consider chiefly externals, and so press for tidiness of hair, but it is hard to imagine that those who emphasize cleanliness of body overlook cleanliness of hair.

Pearson concluded his study of physical measures by proclaiming Jewish children inferior to the native stock in height, weight, susceptibility to disease, nutrition, visual acuity, and cleanliness:

> Jewish alien children are not superior to the native Gentile. Indeed, taken all round we should not be exaggerating if we asserted that they were inferior in the great bulk of the categories dealt with.

The only possible justification for admitting them lay in a potentially superior intelligence to overbalance their physical shortcomings.

Pearson therefore studied intelligence by the same type of short and subjective scale that had characterized his measures of physical traits. For intelligence, he relied upon teachers' judgments rated from A to G. Computing the raw averages, he found that Jewish children were not superior to native Gentiles. Jewish boys ranked a bit higher, but the girls scored notably lower than their English classmates. Pearson concluded, with a striking analogy conjuring up all manner of images in retrospect:

> Taken on the average, and regarding both sexes, this alien Jewish population is somewhat inferior physically and mentally to the native population. . . . We know and admit that some of the children of these alien Jews from the academic standpoint have done brilliantly; whether they have the staying power of the native race is another question. No breeder of cattle, however, would purchase an entire herd because he anticipated finding one or two fine specimens included in it; still less would he do it, if his byres and pastures were already full.

But Pearson realized that he was missing one crucial argument. He had already admitted that Jews lived in relative poverty. Suppose intelligence is more a product of environment than inborn worth? Might not the average scores of Jews reflect their disadvantaged lives? Would they not be superior after all if they lived as well as the native English? Pearson recognized that he had to demonstrate the innateness of intelligence to carry his argument for restricted immigration based on irremediable mediocrity.

He turned again to his correlation coefficients. If low intelligence correlated with measures of misery (disease, squalor, and low income, for example), then an environmental basis might be claimed. But if few or no correlations could be found, then intelligence is not affected by environment and must be innate. Pearson computed his correlation coefficients and, as with the physical measures, found very few high values. But this time he was pleased. The correlations produced little beyond the discovery that intelligent children sleep less and tend to breathe more through their nose! He concluded triumphantly:

> There does not exist in the present material any correlation of the slightest consequence between the intelligence of the child and its physique, its health, its parents' care or the economic and sanitary conditions of its home. . . . Intelligence as distinct from mere knowledge stands out as a congenital character. Let us admit finally that the mind of man is for the most part a congenital product, and the factors which determine it are racial and familial. . . . Our material provides no evidence that a lessening of the aliens' poverty, an improvement in their food, or an advance in their cleanliness will substantially alter their average grade of intelligence. . . . It is proper to judge the immigrant by what he is as he arrives, and reject or accept him then.

But conclusions based upon negative evidence are always suspect. Pearson's failure to record correlations between "intelligence" and environment might suggest the true absence of any relationship. But it might also simply mean that his measures were as lousy as the hair in his category 4. Maybe a teacher's assessment doesn't record anything accurately, and its failure to correlate with measures of environment only demonstrates its inadequacy as an index of intelligence. After all, Pearson had already admitted that correlations between physical measures had been disappointingly small. He was too good a statistician to ignore this possibility. So he faced it and dismissed it with one of the worst arguments I have ever read.

Pearson gave three reasons for sticking to his claim that intelligence is innate. The first two were irrelevant: teachers' assessments correlate with Binet test scores, and high correlations between siblings and between parents and children also prove the innateness of intelligence. But Pearson had not given Binet tests to the Jewish children and had not measured their parents' intelligence in any way. These two claims relied upon other studies and could not be transferred to the present case. Pearson appreciated this weakness and therefore advanced a third argument based upon internal evidence: intelligence (teachers' assessment) failed to correlate with environment but it did correlate with other "independent" measures of mental worth.

But what were these other independent measures: believe it or not, Pearson chose "conscientiousness" (also based on teachers' assessments and scored as keen, medium, and dull), and rank in class. How else does a teacher assess "intelligence" if not (in large part) by conscientiousness and rank in class? Pearson's three measures—intelligence, conscientiousness, and rank in class—were redundant assessments of the same thing: the teachers' opinion of their students' worth. But we cannot tell whether these opinions record inborn capacities, environmental advantages, or teachers' prejudices. I doubt that Pearson took his own argument seriously and was doing more than putting on a brave face by this point. In any case, he concluded with an appeal to bar all but the most intelligent of foreign Jews:

> For men with no special ability—above all for such men as religion, social habits, or language keep as a caste apart, there should be no place. They will not be absorbed by, and at the same time strengthen the existing population; they will develop into a parasitic race.

Goddard's and Pearson's studies shared the property of internal contradictions and evident prejudice sufficient enough to dismiss all claims. But they differed in one important respect: social impact. Britain did not enact laws to restrict immigration by racial or national origin. But in America, Goddard and his colleagues won. Goddard's work on Ellis Island had already encouraged immigration officials to reject people for supposed moronity. Five years later, the Army tested 1.75 million World War I recruits with a set of examinations that Goddard helped write and that were composed by a committee meeting at his Vineland Training School. The tabulations did not identify Jews per se but calculated "innate intelligence" by national averages. These absurd tests, which measured linguistic and cultural familiarity with American ways (a story for another month), ranked recent immigrants from southern and eastern Europe well below the English, Germans, and Scandinavians who had arrived long before. The average soldier of most southern and eastern European nations scored as a moron on the Army tests. Since most Jewish immigrants arrived from eastern European nations, quotas based on country of origin eliminated Jews as surely as collegiate quotas based on geographical distribution once barred them from elite campuses.

When quotas were set for the Immigration Restriction Act of 1924, they were cynically calculated at 2 percent of people from each nation present in America at the census of 1890, not at the most recent count of 1920. Since few southern and eastern Europeans had arrived by 1890, these quotas effectively reduced the influx of Slavs, Italians, and Jews to a trickle. Restriction was in the air and would have occurred anyway. But the peculiar character and intent of the 1924 quotas were largely a result of propaganda issued by Goddard and his eugenical colleagues.

What effect did the quotas have in retrospect? Allan Chase, author of *The Legacy of Malthus*, the finest book on the history of scientific racism in America, has estimated that the quotas barred up to six million southern, central, and eastern Europeans between 1924 and the outbreak of World War II (assuming that immigration had continued at its pre-1924 rate). We know what happened to many who wanted to leave but had no place to go. The pathways to destruction are often indirect, but ideas can be agents as surely as guns and bombs.

*Stephen Jay Gould teaches biology, geology, and the history of science at Harvard University.*

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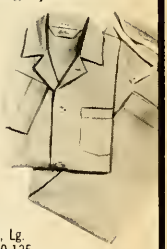

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# Christmas in Jerusalem

*Experiencing the sacred in the Holy Land is, in itself, a miracle*

**by Colin Turnbull**

It is remarkable that such a vital and far-reaching institution as tourism should have escaped the same degree of attention that social scientists give to institutions of lesser consequence. Here is an institution, virtually ignored, that carries millions of human beings backward and forward across the world every year, crisscrossing cultural, linguistic, political, economic, and religious lines with systematic abandon (systematic at least so far as group tours and professionally arranged tours are concerned).

Significantly, serious attention is at last being given to another long-neglected institution, the pilgrimage. Anthropologists, attracted by the exotic and seemingly disinterested in what is right under their noses, may find, however, that the pilgrimage is not as exotic as they think; they may find it alive and well but in the guise of "tourism." Many tourists are engaged in a quest just as much as are pilgrims although, largely because of what they have been told by the tourist industry, they may state their goals as escape, relaxation, and pleasure.

The quest of the tourist is, I believe, often a quest for the sacred, and with this in mind, a colleague and I decided to take a year away from academia and travel around the world, letting circumstances decide whether we were pilgrims or tourists, whether our quest was sacred or secular, and by observing ourselves and our fellow tourist/pilgrims, begin to come to grips with the many far-reaching effects, often unintended and unexpected, that both institutions have on society.

In taking turns to say where in the world we would like to visit, my colleague and I found there was a great deal of agreement between us. Our respective choices were in several instances related directly to religious behavior in cultures where neither of us had worked as anthropologists. It became clear that while personal pleasure and satisfaction were our stated objectives, fulfillment of some kind was an essential part of the goal. At this stage our plans began to look more and more like a research project, and the comparison between pilgrimage and tourism was inescapable.

Although we felt the concept was worth developing into a full-scale research proposal this in no way altered our fundamental position. We clarified certain ideas, but we were also compelled to present plans of action with a detail we knew could never be foreseen. In any case, the foundation to which we submitted the proposal simply could not accept that one of the qualifications we gave for venturing into an area such as Polynesia was that neither of us knew anything about the region except that it is supposed to have idyllic beaches, a friendly and hospitable population, and magnificent cuisine. Yet plainly, if we were to test tourist perceptions by participant observation, we had to be as uninformed about our destination as most tourists and to have similar hedonistic objectives. It is hardly surprising that the project was not funded, but by the time we were notified of this detail we were into our fifth month in the field. And by then we had already reverted to our original plan of passing one year pleasurably without any academic or foundation guidelines to hamper us.

It was a geographical coincidence that Israel was the first stopover on our itinerary, but one that immediately brought us into contact with many of the very real dangers inherent in tourism—some inescapably rooted in the brief duration of the sojourn of most tourists. (In the Mediterranean area Americans in particular are estimated to spend an average of no more than 2.6 days in any one country.) The prime danger of course lies not only in the superficial impressions that tourists get of people and places nor even in the possible, some would say probable, falsity of their understanding of what they see. It lies more in the intensity with which they receive these impressions, whose essential novelty, however true or false, makes them so vivid that they quickly assume the reality of truth in the mind of the tourist. This "truth," and for tourists, of course, it *is* true, they propagate with enthusiasm on their return home: to fellow classmates, at church meetings, at club or business dinners. But are tourists always wrong, are their impressions always so superficial?

Christian tourists in Israel might well be forgiven for getting, very quickly, the distinct impression that not much has changed in two thousand years and that "Hotel Full" signs are being put up for their exclusive benefit. For Israel is a country at war, and although much of the atmosphere of hostility that pervades the country, and much of the discomfiting omnipresence of heavily armed soldiers is obviously due to this factor rather than to any anti-Christian sentiment, the hostile impression is likely to have a

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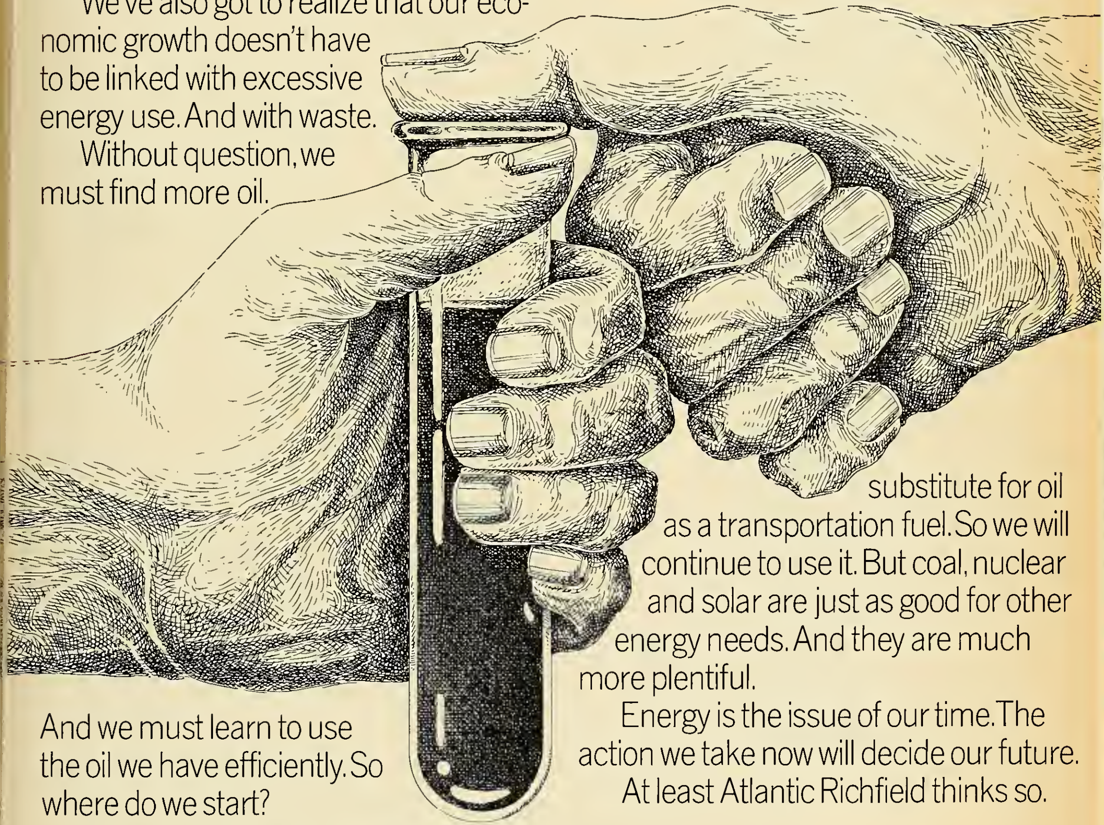

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more lasting effect than the rationalization. Similarly, the Israelis might be forgiven for thinking that Christians, to judge by much tourist behavior, are still a bunch of troublemakers, consciously and unconsciously disrupting the process of efficient government at a time when there is disruption enough. Evidence to support both attitudes is easily found once the attitude has been formed, and a real and enduring animosity can arise all too readily.

For the purposes of this trip I certainly did not consider myself a Christian pilgrim, and I thought I was equally detached from any interest in my cultural and religious history when stretched that far from pagan Scotland. So it was with some surprise that I observed how all this changed.

I found that in a country such as Israel, plainly not a place for the carefree holiday of conventional tourism, tourists are almost instantly compelled to adopt attitudes and opinions whether they want to or not. I began adopting both political and religious stances (or perhaps I was discovering political and religious identities) that were never held previously at a conscious level, even before I boarded the plane at Charles de Gaulle airport.

All of a sudden, for the first time in my life, it came to me that I was a Gentile. It was plain that a miracle had occurred—an agnostic had unwittingly been made to feel like a Christian! That is the power of opposition, and since tourists are, except in exclusively touristic resorts, always a minority in opposition to others, they are constantly being forced to assume an identity, being made to feel more American or whatever, white or black, tall or short, rich or poor, depending upon the nature of the opposition between them and the people whose country they are visiting. The very real danger, not insignificant in terms of international relationships, is that this inherent opposition often manifests itself in hostility, however imaginary or ill-founded.

Having discovered, much to my surprise, that after a long period of neglect I was still a Christian, I began to feel more like a pilgrim. This transformation was completed on my arrival in Jerusalem late that night. The cab ride from Tel Aviv was strangely exciting since it was almost pitch dark. Nonetheless, I filled in the darkness with recollections recalled from the sepia-toned photographs in the Bible of my childhood: deserts, hilly barren land, dusty mud-walled buildings and villages, donkeys, and shadowy figures wearing long, flowing robes. Had it been daylight, my imagery would not have been far different. Soon there was a glow in the sky, lots of stars in the east, and we were suddenly under the walls of the old city of Jerusalem, following them past the Damascus Gate to Herod's Gate, where we turned off into a little side street and pulled up at the Holy Land Hotel. In the light of the street lamps, Jerusalem was as sepia-toned as those photographs, people wore the same long robes, and I was reminded of the life-sized Nativity scenes that fill our churches and department store windows every Christmas. The Christmas feeling was completed when the hotel, despite our reservations, said they were full. However, they suggested, not exactly a stable, but a humble adjoining annex where we did indeed find shelter.

The Christmas spirit was quickly dampened the next day. Setting off early with the enthusiasm of a pilgrim, and with my rediscovered identity as a Christian, I found that within the walls of the old city the stores were as colorful and bright with tinsel as any New York department store—and just as full of junk being sold at ludicrous prices to Christmas shoppers (tourists) who seemed consumed by a compulsion to buy something or everything. I began to feel less Christian. Both the Christian and the Christmas spirit were further dispelled in the one place I thought might possibly revive them—the tomb of the Holy Sepulcher—partly because of the behavior of my fellow tourists, who seemed to manifest a blatant lack of respect for the sacred by their flagrant use of cameras, despite signs prohibiting them. I found the flash gun particularly offensive, illuminating as it sometimes did people at prayer, invading their privacy and despoiling their sanctity. Other tourists pushed and shoved in a very un-Christian way, using shoulders and elbows to force a way through the narrow entrance to the sepulcher itself. Occasionally a minor fight broke out, accompanied by swearing and gestures that were anything but sacred.

The clerics in charge, far from restoring an air of sanctity, dispelled any illusion of holiness by themselves setting the pattern for aggressive behavior. One brown-robed, heavily

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As we develop new waste-disposal techniques, we share our knowledge with industry, government and the public. In 1979, we began conducting a series of regional seminars that presented current techniques for solid-waste disposal. Individual companies may use videotapes, visual aids or other techniques to train personnel in waste-disposal methods.

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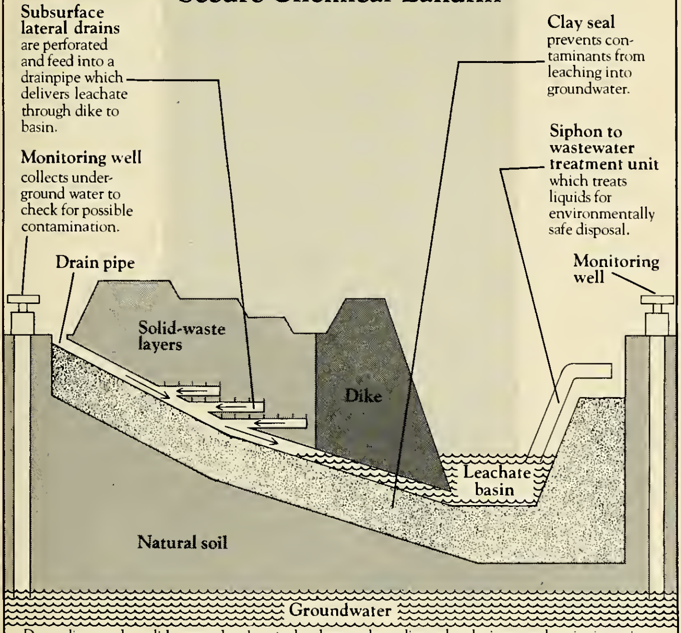
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cowled, Rasputinlike figure imperiously swept the common tourists back from the sepulcher entrance each time a group of higher paying, candle-bearing tourists (called pilgrims) came into view, led by yet another Rasputin. This generated hostility between non-candle-bearers and candle-bearers, as well as between the various clerics, as there seemed to be an endless succession of rival sects competing for time and space, and of choirs filling the air with competing sounds, adding to the general commotion.

Looking for my colleague I found him a few yards away at the rear of the shrine, down on his hands and knees, half hidden inside a hole in the wall. As I watched, his right hand came out and groped blindly for some money in his pocket, but his other arm remained inside, stretched as if held. Once he had transferred the money back inside the hole, however, his left arm was released and my friend stood up, looking very embarrassed (he was an atheist); in his left hand he held a microscopic wooden cross, wet where it had been sprinkled with allegedly holy water by the monk who had that concession and crouched concealed inside the little cavern, waiting for his prey.

The lovely and historic streets of Old Jerusalem, crying out to be respected and loved, suddenly became unwholesome, distasteful, and alien to me, beautiful only when empty of tourists and pilgrims, clerics and commercialism. It was the same almost everywhere, from Bethlehem to Nazareth, down on the shores of Galilee and up on the summit of Mount Tabor. The tourist industry, which attracts the money that helps preserve the monuments that attract the tourists, is paving the way for the destruction of the very source of its attraction. Tourists seeking the sacred, to touch and be touched by it, desecrate it by their very eagerness and haste, just as the competing sects desecrate the sacred by their very competition and commercialization.

But then I realized that I had slipped from my role of being a tourist; I was being too academic and was consequently missing the whole point. Despite their own, not inconsiderable skepticism about the authenticity of either the sites or the stories told about them, many tourists suspend that skepticism just long enough to allow themselves to be touched. "Oh well, I might as well do it just for fun . . . here, hold my bag, dear," said one lady with a strong Midwestern accent as she stepped forward to kneel down and kiss the star above the site of the Nativity, in Bethlehem. She arose, blushing with embarrassment because she had stayed down on her knees a shade longer than required "for the fun of it." But behind the blush she was radiant, her spectacles were positively foggy, and she walked off without a word, forgetting her friend and her bag.

I saw tourists breaking their own sacred rules of touristic hygiene and drinking water from Jacob's Well, allowing some priest to sell them a piece of the true cross, standing in quiet contemplation of the stark countryside, and walking at Qumran and Masada, where man attacked man with intellectual and religious bigotry so long ago, or frolicking in a garish seaside resort suitably located near the ancient site of Sodom and Gomorrah. Even there, the shadow of Masada touches the frolic, and the experience of being totally unable to sink in the bright blue, salty water of the Dead Sea turns out to be a miracle rather than "just fun, dear."

There are ugly tourists to be sure. Some will remember only the inconveniences, the stopping and searching at every checkpoint, and they will find the Holy Land very unholy as, in a way, I did. But then I too was touched, not so much by the shrines or by the magnificent countryside that commands such a fierce attachment from all who live there, but by the glow on the face of that woman who kissed a probably phony slab of rock and by the countless others like her, who did something "just for the fun of it" and were touched because they were not really tourists at all. They were true pilgrims who brought the sacred with them, unknown to them because it was locked so deep within their being. I suspect that the quest of many a tourist, the "fun" they are really looking for, is the unlocking of that inner part of themselves. And whether it is Christmas or not, at war or at peace, and almost in spite of itself, the Holy Land still has the power to work that miracle.

*Colin Turnbull, formerly associate curator of African ethnology at the American Museum of Natural History, is visiting professor of anthropology at George Washington University.*

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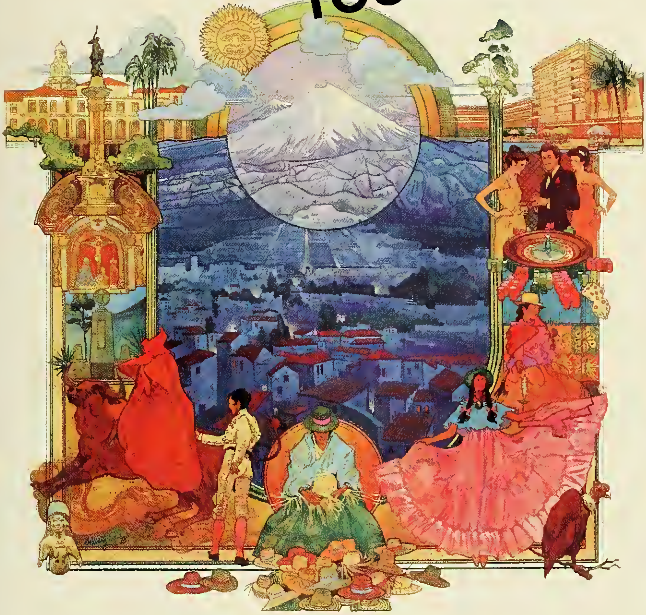

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# The Miracle of Intervale Avenue

*Aging Jews cling to their synagogue amid the decay of the South Bronx*

**by Jack M. Kugelmass**
**photographs by Yoav Levy**

The two men, one sipping sweet kosher wine, the other taking his regular Sabbath shot of Scotch, both nibbling on an assortment of honey, sponge, and marble cake, were engaged in the usual conversation that accompanies the kiddush—the benediction over wine that follows the Saturday morning services.

MR. ABRAHAM: I'm telling you, Moishe, if they put a cop in the building, it's more trouble than it's worth. We had a cop in our old shul [synagogue] before it closed. He used to make long-distance phone calls, put the heat up until it was 90 degrees, put the air conditioning on, and sleep on the benches using *talesim* [prayer shawls] for a cover.

MR. SACKS: Mr. Abraham, I got nothing to worry about. They aren't going to put a cop in here. And if they do, he can't put the heat up to 90 degrees because I don't have a boiler. If he wants air conditioning, he'll have to open the windows. And if he wants to sleep on these hard benches, I wouldn't deny him the *talesim* for a pillow.

The question of increased police protection for the building was the main topic of conversation on this particular Sabbath because, two days earlier, several youths had been arrested on charges of breaking and entering. They did not take much since there was little to take. Mr. Sacks's prayer shawl and prayer book were the only things missing, and these were now in police custody being held as evidence. Most of the damage resulted from petty vandalism. Some old and tattered Hebrew books had been swept off the shelves and scattered on the floor, kosher wine had been sprinkled on the carpet, and the cloth hangings separating the men's section from the women's section had been torn down.

The shul—the Intervale Jewish Center—stands in the heart of the South Bronx, a part of New York City inhabited predominantly by Puerto Ricans, interspersed with pockets of black residents. Crime, arson, and urban decay have been so widespread in this area that the 41st Precinct, in which the shul is located, was nicknamed "Fort Apache" by the police. Like all local institutions, the shul is subjected to repeated vandalism from marauding groups of youths, although it is so denuded of

*A weekly concern of the small congregation is to achieve a minyan, or quorum of ten men.*

artifacts that there is scarcely anything left to steal. The silver ornaments that decorated the Torah scrolls disappeared years ago, and a large, discolored patch indicates the space on the wall from which vandals removed the bronze memorial plaque listing the names of deceased members of the congregation. The roof, too, has suffered from numerous attempts to penetrate the building. Periodic downpours have left the building with a musty odor, rotting wood floors, peeling paint, and falling plaster. The Torahs, hidden from view inside the Holy Ark, are covered with plastic garbage bags to protect them from the rain.

Some of the decay is a consequence of the shul's declining membership and the diminishing finances of the few remaining congregants. Built in 1923, when the south and central Bronx contained more than a quarter-million Jews, the shul could then barely house the hundreds of White Russian-Jewish immigrants who competed for seats. Nearby, rows of stores catered to the culinary needs of observant Jews. Today, the once plain but solid rows of middle-class houses and apartment buildings are pockmarked by vacant, rubble-strewn lots. Dug into the ground like an exposed bunker, the shul seems to shrink from its neighbors: an abandoned six-story apartment building on one side; a garbage-strewn lot on the other.

Inside, a half dozen stairs lead down from the entrance to a main hall large enough to seat five hundred people. The dozen or so congregants who still attend services are scattered throughout this room. Some sit alone, others in small groups. A few roam about the hall, checking for needed repairs, while others busy themselves at the rear of the shul, preparing the food and wine for the kiddush.

On one side of the main hall the windows are boarded over with plywood. Two velvet Torah covers, white and purple, hang beside a large, red cloth tacked onto one of the sheets of plywood. The Torah scrolls they once contained were donated to a synagogue in Israel. These empty covers are not the only reminders of the decline of the Jewish community in the neighborhood. Covering the lectern for reading the Torah are several layers of white, orange, and red velvet, each with its own gold embroidery indicating the name of the congregation to which it once belonged. These hand-me-downs from other synagogues give the shul the quality of a survivor whose task it is to bear witness to the fate of a much larger collective. Like the artifacts, the congregants found their way to the Intervale Jewish Center after other neighborhood synagogues closed. They remember their synagogues when they were filled to capacity and were the cornerstones of a vibrant neighborhood.

In the face of this decay, Mr. Sacks's defiantly humorous remarks about having a policeman in the building reveal a justified optimism in the shul's future. Although the shul suffers from financial problems and the constant threat of vandalism, neither poses an insurmountable risk. Over the years, the most serious question the shul has faced is whether or not it can assemble the minyan—the ten adult Jewish males who constitute a quorum for ritual purposes. Despite the age and frailty of the congregants and the neighborhood's reputation, the minyan has, with

*Roguishly covering his face like a wanted man, Dave Lentin allows a photographer in his home.*

few exceptions, continued week after week, year after year. As Mr. Sacks explained to me during our first conversation, "When one person leaves or dies, someone else seems to come along to take his place. This is the miracle of Intervale Avenue."

I quickly learned that I, too, was part of the miracle. As an adult Jewish male who visited the shul on a regular basis, I became a member of the minyan. Presumably, when my study ended, someone else would come to take my place. Nor was I the only outsider to visit the shul. Besides the occasional calls by reporters there are those who have established a more enduring relationship with the congregation. One man, who commutes from Long Island to manage a local department store, attends the Sabbath minyan regularly, while another, a store owner, drops by from time to time. In addition, two groups of Jewish volunteers maintain contact with the shul, providing "care packages," outings, and other assistance to the congregants and the score of other Jews who live in the area. One of these organizations even arranged to have CBS News visit the shul and broadcast the activities the group had sponsored. Some members of the congregation relish the glamour of media exposure and enjoy having photographs to send to children and grandchildren. Almost all are receptive to outside publicity, hopeful that it will help preserve the minyan and the building in which it is housed.

The congregants, mainly elderly, are a motley group. Most are Ashkenazic Jews who emigrated from Eastern Europe in their youth. A few are black Jews, who consider themselves descendants of the union of Solomon and the Queen of Sheba. Aside from their concern for the shul and their need for religious expression, little holds them together. Most live scattered throughout the neighborhood, far from each other. Their closest ties are to friends and family who live elsewhere in the metropolitan area. Also intense are their ties to deceased spouses, parents, and sometimes siblings. Memories are one important reason they remain in the area; another is the shul and the pride taken in maintaining the minyan. In the words of one member, "When the shul goes, I go." Then, too, there is the relative comfort derived from living an accustomed life in a familiar neighborhood. When I asked one 86-year-old woman why she had never considered moving to Miami, she exclaimed: "Miami? It's not safe there. It's worse than New York!" Another woman responded with equal alarm at the thought of moving to a better neighborhood: "And now where could I go. To a neighborhood where I'll be a stranger, a strange woman ringing the bell, an old woman. They hate old people."

For such elderly people, independence and self-esteem are closely related. These are not people who have been abandoned by their children. On the contrary, they have chosen to live independently, among their peers. One 82-year-old woman, who acts as secretary for the shul, explained why she would not move into her daughter's suburban home, despite repeated invitations to do so:

> I like to be like a guest. I'll never forget a few years ago, unexpectedly visiting my daughter. I didn't tell her I was coming. But when my grandson saw me coming, he didn't

*Elsie Miroff's seamstress shop gives her contact with the street life she enjoys.*

run toward me. He ran upstairs to tell his sisters, "Guess who's coming. Granma's coming!" You see, if I lived there, I wouldn't hear all this, would I?

What is most striking about these people is their ability to lead active lives in an area where few New Yorkers care to venture, let alone live. Their determination is all the more remarkable considering their advanced age and physical vulnerability. The neighborhood, like their age, sets the framework within which they live, but it does not determine, in a deeper sense, the quality of their lives. For most of them, the decay of the South Bronx is an adversary much like death. It is inevitable. One cannot flee from it, yet some form of resistance is necessary. When an aged person succumbs to decay, he is at death's threshold. These people are very much alive.

Dave Lentin tells me that he is a wanted man. He shies away from television cameras and resents the intrusion of his space by reporters. Dave is a killer. As caretaker of the shul, it is his responsibility to poison the rats and dispose of their bodies. Dave hates rats. He also hates to kill.

Dave is sixty-nine years old. His boyish grin and verbal antics are a mask, suggesting the trickster nature of his character. "People think I'm nuts," he says, "but that's just to fool them. Like a cat plays with a mouse. The cat acts like he's playing. When he's ready, he pounces." Dave's antics provide a humorous counterpoint to the seriousness of the other men. He typically responds to a Yiddish greeting with a Spanish one. Or he pretends not to know the difference between Yiddish and Spanish, rabbi and priest, Jew and non-Jew. He loves to mimic the other men. When he engages in the customary handshaking after performing part of the Sabbath ritual, he carries it to an extreme by pumping each and every hand in the shul. He often replaces the traditional Hebrew benedictions with homonymous English words or phrases. No one seems to mind.

Dave's trade is sign painting. His labor is everywhere in evidence, both outside and inside the shul. Some of his signs are multicolored paintings. Others are simple, graffitilike words or phrases in Hebrew or English. Typical of his work are the two hand-lettered signs on the inside of the twin doors that close the main room from the entrance hallway: *am yisroel khay* ("Let the people of Israel live!") and "Thank you—Come Again." Dave often talks about his ideas for covering up the broken plaster and the peeling paint. One is to paint the ceiling with a Biblical scene of Adam and Eve, "maybe with, maybe without fig leaves. I haven't decided yet."

Dave also works as a caretaker at a local senior citizens' center, where his lettering decorates the cover of the minutes book. He invariably sneaks a Hebrew word in with the Spanish, explaining to the Spanish-speaking members of the center that the letter ש ("shin") is not a letter at all, but a picture of three men in a boat. In exchange for his work, Dave receives a small salary. He also accumulates Spanish benedictions, which he dispenses like weapons of self-defense to disarm and charm.

Despite his preoccupation with Hebrew lettering, Dave's

*As surrogate mother to Betty (second from left), Mrs. Miroff (right) has earned her neighbors' respect.*

knowledge of Hebrew is not very extensive. His own religious training did not begin until his mother died twelve years ago. Dave was initially unable to cope with the loss. Eventually, he pulled himself together, partly through the help of a local rabbi who taught him how to recite the kaddish, the Jewish prayer for the dead. Dave learned the words in a few days by repeating them over and over again. He continues to repeat the words whenever he can. When he sees a dead animal or tree, he says kaddish. As Dave explains: "Trees are part of God's universe. Look at their branches. They point upward to God, not down. Down there are rats. I won't say kaddish for them. They belong to the devil. Let him say kaddish for them!"

Although it is customary to say kaddish for one year following the death of a loved one, Dave continues to recite the prayer at Sabbath services each week. He pays scant attention to the rest of the service, roaming about the shul and joking with the people. But when it is time to say kaddish, he races to the front of the hall and recites the prayer, as he says, "from the heart." This is one of the few activities Dave performs with a completely straight face; the one time he joins the congregation as an active member, contributing to the service and deriving satisfaction from it.

In a congregation this small, a person's presence is itself a contribution. Still, Dave is tolerated not simply because he is needed for the minyan. He also represents something. The other men encourage him to say kaddish, as if his prayer stood for the mourning of the congregation as a whole. In a sense, Dave is an archetypal kaddish, the male child whose prayer protects his parents in the other world. His prayer has ceased being the prayer of one son for a deceased mother. It is the prayer of all children for all parents. Some members of the congregation have survived their own children. Others are uncertain of their children's religious devotion. For all of them, Dave is a kaddish. He is the caretaker of the shul in this world, the caretaker of the congregants in the next world.

Almost all the congregants have exercised some amount of choice in remaining in the neighborhood. Dave, who does not consider the neighborhood particularly dangerous, is one of the few who probably has no other option. Moishe Sacks, who does consider the neighborhood dangerous, has many other options. He is politically astute and has many contacts among city and private Jewish agencies. His children are accomplished professionally and could help him settle elsewhere. Moreover, he is employed as a baker and could be considered relatively well-to-do.

Nevertheless, Mr. Sacks, like the others, is tied to the area. Although he tried to settle in Israel seven years ago, he kept his apartment in the South Bronx in case he returned. And he did return because he could not find a suitable job in Israel, although he even offered to pay a baker to let him work. In the South Bronx, he works a sixteen-hour shift each weekday, and his labor and organizational skills keep both a bakery and a shul afloat.

*The synagogue reflects the poverty of the small congregation and the ravages of vandalism.*

Sacks is a defiant man, who refuses to retire although he is well into his seventies and has a serious heart condition. And he resists closing the shul despite repeated vandalism. The police have suggested that the congregation find safer quarters in which to pray, but Sacks adamantly refuses to abandon the building: "If we give in to vandalism and go elsewhere, we won't be any safer. If they chase us out, no one is safe anywhere."

Nevertheless, vandalism and the deteriorating neighborhood have been getting the better of the shul. Membership has declined, and functionaries, both religious and secular, have left. Because of the age of the congregation, weddings and bar mitzvahs are no longer celebrated. Benefactors are few. Sacks has taken on a variety of roles in order to provide a full range of services to the congregants. He actively solicits and welcomes new members, takes an interest in their welfare, and lends a hand to those who need help. Although he lacks formal religious training, he has become the unofficial rabbi of the shul. He is the acting president as well as the caterer and the social director. Even the operating budget of the shul comes from his own pocket. The minyan survives because of the combined efforts of many people. The shul survives because of Mr. Sacks. The congregants know this and are extremely respectful toward him. He is equally respectful toward them. He enjoys the positive impact he has on other people. "I'll admit it quite frankly," he says in explanation of why he stays. "Here I'm a big fish in a small pond. It's better than being a big fish in the ocean."

As capable as Sacks is in presiding over a congregation of diverse people whose roots in the shul are not very deep, he is equally adept at gaining the confidence of people from outside the shul. The bakery is a neighborhood institution where those who are hungry and without money can eat. Sacks makes certain that leftovers are saved and distributed to derelicts and others who are down on their luck. In this way he can rely upon a network of friends and neighbors for protection. He maintains good relations with members of the police department; some off-duty officers regularly escort him to work for the midnight shift. Even local youths consider him to be a confidant and an intermediary with the police.

The Jews in the South Bronx do not live in a ghetto within a ghetto. They are dispersed throughout the neighborhood. They tend to be the only Jewish person in their building or on their block. They are sociable human beings. They understand people, and they have learned how to live apart from their families and other close friends. These people are not survivors merely by accident. Members of the congregation know how to establish bonds of obligation within the neighborhood. One woman collects all the leftover food from her senior citizens' center and distributes it on her block. Others use charm or friendliness as a way of reducing the dangerous effects of anonymity. They greet and expect at least a grudging "good day" from passers-by, and they talk to everyone, old or young. But few are as resourceful as Elsie Miroff in establishing her position in the neighborhood.

Mrs. Miroff is eighty-two years old. She suffers from

*The principal organizer of the synagogue is Moishe Sacks, who is a baker by profession.*

a failing voice, shortness of breath, and hypertension. The trip to shul is an effort for her. She is not always well enough to walk the dozen or more blocks, and she fears for her safety the moment she leaves the narrow confines of her immediate neighborhood. Despite her frailty, she takes charge of bringing wine for kiddush and coffee for Sunday brunch. Like Mr. Sacks, Mrs. Miroff commands a good deal of respect from the other congregants.

Mrs. Miroff guards her independence fiercely. She maintains a seamstress shop in a dimly lit, narrow storefront next door to her apartment. The small room is cluttered with clothing that people have brought to be repaired. Most of the clothes are never claimed by their owners. Mrs. Miroff sits at her sewing machine in the front of the shop and occasionally looks out the small window through a metal grate that a neighbor fashioned for her. Her shop gives her an important point of contact with her neighbors. It is well heated in winter and cool in the summer. People on the street are welcome to drop by to talk and to warm up or cool off as the case may be. In addition, Mrs. Miroff has some half dozen chairs stashed away, which she lends to various men who sit outside the shop, a choice location because it is next door to an illicit numbers parlor.

Without her shop, Mrs. Miroff would feel trapped in her apartment, shut off from the street life that she enjoys so much. Rent is cheap, and her Social Security checks cover the cost of the apartment and the shop. She could not afford to maintain both anywhere else in the city. Mrs. Miroff sees herself as a giver, not a taker. It is an important source of pride:

> This is it. From what I make, I got enough for wine for kiddush, for a donation. This is it. Give a few dollars to who I want to give. This is not a luxury life, but it's a life. And not to take by anybody anything. Is that the best? You agree with me?

How could I argue otherwise?

There is another reason Mrs. Miroff prefers to remain in the neighborhood. She is very attached to her present apartment, where she has lived for forty-two years. She raised her family in it, worked as a seamstress in it. And her husband died in it. Her memories are so closely connected to the apartment that she is unwilling to part with it. She also feels comfortable there. Despite the decline of the South Bronx over the past fifteen years, it is home. Still, her sense of security is not a passive outgrowth of long-term residence, but a direct result of an active pursuit on her part.

Betty is a constant visitor to Mrs. Miroff's shop. Betty is black. She is forty years old and retarded. The relationship between Mrs. Miroff and Betty goes back seventeen years, when Betty's family first moved into the building and Mrs. Miroff's husband died. The two women have been close companions ever since. Just over a year ago, Betty's mother abandoned her and left her in Mrs. Miroff's care. The neighbors refer to Mrs. Miroff as the "white nigger" because of her role as Betty's surrogate mother.

Betty needs guidance and companionship. Beyond the confines of her immediate home neighborhood, Mrs. Miroff needs a protector. Betty accompanies Mrs. Miroff to shul and sits with her during the services, patiently waiting for the kiddush cake or Sunday brunch. In a way, Betty fits in among the congregants. Her hand-me-down clothes from Mrs. Miroff's shop are no different from the clothes worn by other members of the congregation. The decay of her body, most visible in her toothless mouth and obesity, makes her all the more indistinguishable from many elderly Jews.

Mrs. Miroff refers to Betty as "mine bodyguard," and the members of the shul accept Betty as her appendage. Although Betty could not really protect Mrs. Miroff in the event of an assault, Mrs. Miroff feels safer walking beside her. Being seen next to "a black face," as she puts it, lends her respectability in the neighborhood. And her feeling of security appears to be justified. By looking after Betty she has gained the respect and admiration of her neighbors.

For Mr. Sacks and Mrs. Miroff, and for many others who participate in the services, the shul is a focal point of their lives. For some congregants, it is the only reason they remain in the neighborhood. Each action on behalf of the shul is meaningful and gives status and self-esteem to the person who performs it. From serving the food to reading the Torah, each task seems important.

The shul is a source of pride, a concrete symbol of defiance and perseverance that closely resembles the people it serves as a house of worship. It is an aging, decaying structure whose "looks," if they ever existed, have long since disappeared. Its shabby, drab exterior resembles the tattered clothes of the congregants and the plastic shopping bags they carry at their sides. And yet, the shul is still standing and in regular use. It has outlived every other shul in the area, most of which were wealthier and more beautiful. Above all, it continues to get, week after week, the minyan of ten men. As long as the minyan is intact, its individual components are secure.

Although the benedictions over the Torah and the kaddish cannot be recited without the minyan, most of the rest of the service remains the same. Still, the minyan is of vital concern. On the rare occasion when a tenth man is unavailable, the minyan is considered complete with only nine, since (according to Mr. Sacks) God stands in for the tenth man. The cantor, however, opposes accepting nine men as a properly constituted minyan. One Sabbath, during kiddush, I asked Sacks how there could be this disagreement.

"You see," he explained,

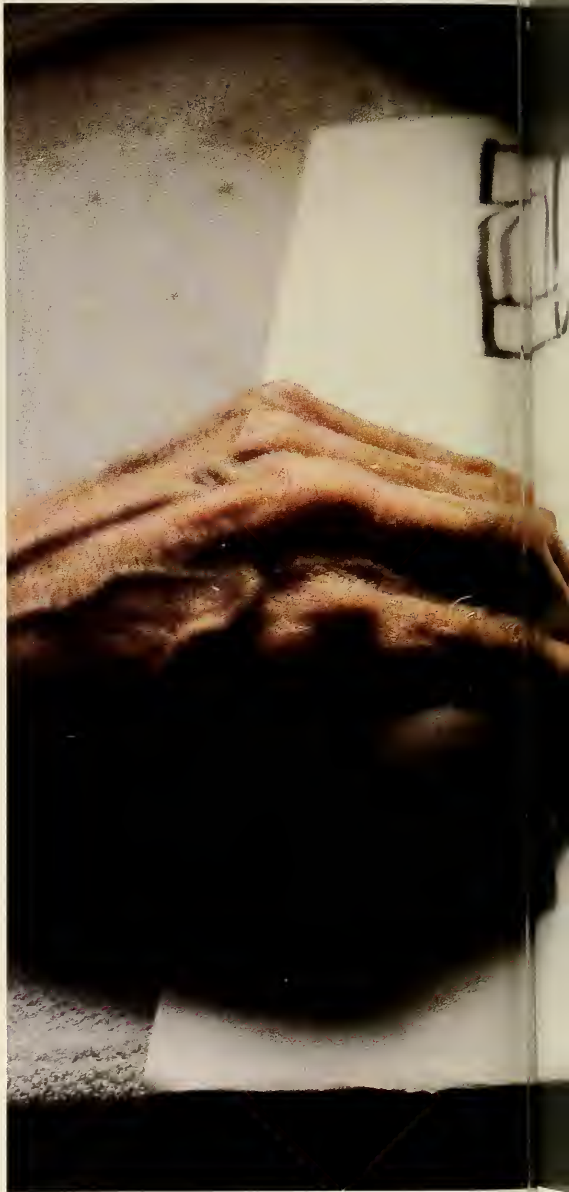
> when God told Abraham that he would destroy Sodom unless fifty righteous people could be found there, Abraham asked God whether he would do it if there were only forty-five righteous people. God said he would not. Abraham got braver and asked whether he would do it if there were forty righteous people. God said no. Thirty? No. Finally Abraham asked whether ten righteous men would save Sodom. Again, God replied that he would not destroy Sodom if ten righteous men could be found. At that point Abraham knew that he could not ask for anything more, and he walked away.

"So," I replied, "that explains why ten are needed for the minyan. What about nine? How do you arrive at the figure nine?"

"Well," Sacks responded,

> we don't know exactly. But Rashi, the great commentator, says that at the time of the flood there were only eight righteous people—Noah, his wife, their three sons, and their wives. There were eight righteous people, and God destroyed the world. So we know that eight righteous people are not enough to save the world. But nine we don't know. So if we don't know, we can hope that nine is enough.

As long as the minyan exists, some semblance of the world that Mr. Sacks and other members of the shul knew and loved survives. By keeping the shul alive, they are indeed staving off the destruction of a world.



The Sabbath is not always strictly observed at the Intervale Jewish Center. Sometimes repairs must be made or extra nails hammered into place to buttress the shul against vandals. One Sabbath, Moishe Sacks and Sam Davis stood outside and examined the metal-covered door of an unused entrance that had been partially damaged the day before. I stood there too, contemplating the motives for the damage and listening to the conversation between the two men.

"Mr. Davis, did you bring your hammer?"

"Sure I did. When a soldier goes to war, he brings his gun. My hammer is my gun. This is a war!"

Mr. Sacks liked the metaphor. He thought for a moment, smiled, and then commented: "You're right. This is a war. Your hammer is your gun, and my [prayer] books are my gun. And his . . . [he pointed to me and hesitated, because I did not have my tape recorder with me that day] whatever he has, that's his gun."

I too was pleased with the metaphor. I smiled and decided to remember the conversation. ☐

*Dave Lentin letters one of his signs: "Shalom . . . ."*

Dan Budnik, Woodfin Camp and Associates

# Needs of Weeds

*Prodigious propagators and able opportunists, weeds prepare the way for longer-lived plants*

**by John C. Kricher**

America is often referred to as the "land of opportunity." Waves of human immigrants from many countries have come seeking a prosperous life in the New World. *Homo sapiens*, however, is far from the only species to succeed in colonizing America. Dandelions, crabgrass, Queen Anne's lace, lamb's-quarters, sheep sorrel, and even bluegrass are but a small sample of a large constellation of alien plant species that have been assimilated into the ecology of North America. Having successfully invaded an area in which they did not evolve, these immigrant species, commonly referred to as weeds, share their North American habitats with such native weed species as common ragweed, asters, and goldenrod. Weeds may be the scourge of gardens and the cause of allergies, but their role as colonizers is vital to the health of ecosystems. An examination of the needs of weeds and their awesome array of adaptations provides a substantial lesson in the workings of ecology and evolution.

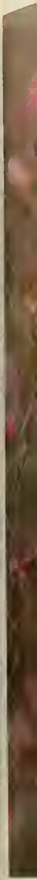
Weeds are plants whose populations grow wholly or predominantly in areas that have been markedly disturbed. Lawns, roadsides, gardens, gaps that appear in a tropical forest after a blowdown, and recently abandoned agricultural fields are ideal habitats. The key words in the above definition are "markedly disturbed." Mature forests pose no threat to ragweed sufferers since ragweed, like other weeds, cannot grow in deep forest shade. A newly disturbed area, however, flooded with sunlight and devoid of competitors, provides optimum conditions for any organisms that can, first, find the area (that is, disperse well) and, second, grow and reproduce with vigor. Whole ecological communities are reshuffled and the intense game of ecological competition begins again in these temporary ecological vacuums, which offer opportunities for invasion by enterprising species. Weeds are the champion biological opportunists.

In a field that has been plowed under, abandoned, and allowed to remain fallow, a sequence of events occurs that is known collectively as ecological succession. Following a disturbance, such as plowing, different plant communities occupy an area in a characteristic sequence. In time, the rate of succession slows down until most species present are self-replicating, and whatever constitutes the normal type of ecosystem for that particular geographical area is reestablished. In the Northeast, a forest will eventually develop. Weeds are always the initiators of this process, the first colonizers. Why, in a bare, plowed field, don't oaks, maples, and hickories simply populate the area immediately? Such an event never happens. Trees, which will be the major species at the cessation of the succession, only begin growing fifteen to twenty years after the field is abandoned. Prior to the appearance of trees, the field is the exclusive realm of herbaceous and woody weed species—the ragweeds, dandelions, fleabanes, asters, goldenrods, poison ivy, and grasses.

A comparison of a white oak tree with a common dandelion will make clear why trees cannot be the first colonizers. To colonize an area, a species must first insure that its propagules arrive there. Good dispersal powers are essential. Since wind is more pronounced in open areas, species that exploit wind for dispersal

*Dandelions in seed*

Robert P. Carr



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*Black-eyed Susans*

Robert P. Carr

are at an advantage in finding such sites. Acorns, the seeds of oak trees, are relatively heavy and must be transported by animals such as blue jays and gray squirrels. An acorn could not reach a disturbed site easily. By contrast, dandelion seeds, like seeds of virtually all weed species, are wind dispersed. The tiny seeds weigh almost nothing, and helped by their delicate "parachutes," they drift like dust specks. People often aid in dandelion dispersal by blowing the flower heads for amusement. Milkweed and thistle are other well-known examples of wind-dispersed weeds.

Weed seeds not only travel easily; they are also plentiful. Weeds, many of which are annuals, devote huge amounts of energy to reproduction. Ecologists Sandra Jo Newell and Elliot Tramer of the University of Toledo found, for example, that common lamb's-quarters, an abundant annual, produces an average of 4,820 seeds per plant. Some individual plants produce as many as 50,000 seeds. Measured in terms of weight, the average common lamb's-quarters plant devotes fully 25 percent of its energy toward reproduction. To appreciate the magnitude of this effort, we need only compare these figures with those obtained by Newell and Tramer for cut-leaved toothwort, a common forest wildflower. An inhabitant of stable woodlands rather than disturbed fields, the toothwort produces an average of 24 seeds per plant. The highest seed count for a given plant is 42; the overall reproductive effort by weight is only one percent.

Unlike trees, weeds are adapted to reproduce prodigiously rather than to persist for long periods. One indication of this is the large numbers of annual and biennial species that have evolved. I studied weeds in two fields in New Jersey: one was only two years post-abandonment; the other had been unused for thirty years. The two-year-old field consisted entirely of herbaceous species, of which fully 47 percent were either annuals or biennials. The thirty-year-old field, in contrast, consisted largely of perennial grasses, shrubs, and trees. Of the herbaceous species in the thirty-year-old field, only 21 percent were annuals or biennials. The more persistent, rather than the rapidly reproducing, species were coming to dominate the ecosystem as it aged.

Each weed seed is a miniature time bomb, able to remain dormant almost indefinitely but set to explode into germination when the time is right. Many cases have been documented of the successful germination of weed seeds found in anthropological sites hundreds of years old (see "Long-lived Seeds," *Natural History*, February 1979). The seeds wait, in a state of suspended animation, for the inevitable fire, hurricane, or ax that will destroy the forest and provide the sort of environment in which they thrive. Only then will they quickly germinate and live out their short lives making more seeds. Acorns, in contrast to weed seeds, lack longevity. Most will be eaten or succumb to fungal rot within a year or two after falling from the parent tree.

An understanding of the herculean reproductive powers of weeds forces us to redirect the previous question about why oaks, maples, and hickories do not populate disturbed areas immediately. Indeed, considering the reproductive abilities of weeds, we must ask, Why do tree species ever appear at all? The answer to this question is found in the adage "You can't have it all ways." In maximizing their genetic energies toward high dispersal and reproductive powers, weeds have little energy left to cope with potential competitors. As a further complication, weeds must also devote much of their energies to maintaining themselves in physically rigorous environments. Disturbed areas are often windy, sunbaked, and subject to intense erosion. Weeds are adapted for pioneering, not for persisting.

*Aster pilosus* is a pioneering plant found in many abandoned fields and along roadsides. David L. Peterson and Fakhri A. Bazzaz of the University of Illinois studied the life cycle of this common aster and learned that the plant makes "choices" relative to how it reproduces. An aster germinated in spring may flower late in the summer and set seed. Or it may, in response to competition for nutrients with other plants such as ragweed, not flower but assume a prostrate dandelionlike rosette form and pass the winter hugging the ground. The rosette is not dormant and actively photosynthesizes during the cold months. The following spring, if nutrients are sufficient, the aster will "bolt" and grow rapidly, flowering and setting seed early. Finally, in favorable environments, asters frequently also spread by reproducing vegetatively. The reproductive characteristics of the aster are clearly directed toward opportunism. As succession proceeds in an area, asters cannot compete with other plants for prolonged time periods. They must seize their moment, reproduce, and then perish.

Fakhri Bazzaz also studied common ragweed and learned of the physiological adaptations that enable it to cope with life in open fields. Ragweed can photosynthesize rapidly, adding as much as 14 grams dry weight per meter squared per day during favorable periods. The species manages this through a genetic ability to tolerate, and indeed to thrive on, very high light intensities that would inhibit photosynthesis in most other plants. In addition, ragweed photosynthesizes over a very wide range of temperatures and under high concentrations of carbon dioxide, conditions characteristic of open areas. Finally, ragweed demonstrates a phenomenal ability to recover rapidly from drought. In a word, ragweed is physiologically tough. It has, however, apparently paid an evolutionary price for its skills. Once it has become established in a field, its prevalence begins to decline rapidly. A first-year field may contain a dense stand of ragweed plants, each in excess of three feet tall. The second summer, however, the ragweed plants are stunted and may be only about six inches tall; all are destined to disappear entirely by the third summer. Catherine Keever studied a similar stunting phenomenon with horseweed on abandoned fields in North Carolina. She learned that the stunting is caused both by the competitive effect of other species, such as the asters, and by the decomposition products of horseweed's own roots—horseweed actually poisons itself! Evidence indicates a similar situation for ragweed.

These observations have one prac-

*Apple tree in abandoned, weed-dominated orchard*

tical application: spraying tall ragweed clumps with herbicide is probably not a good idea. Doing so only "sets back" the succession by reestablishing the disturbed condition and insures that a new and vigorous crop of ragweed will invade the following year. Leaving the ragweed alone, on the other hand, will, within a year, lead to its probable disappearance through self-destruction and loss to competing species.

The significance of the ragweed example lies in its emphasis upon ragweed's range of adaptations, which allows it to exploit environments that would be insurmountably severe for most species. By merely being there, ragweed dramatically alters the ecosystem, reducing its physical severity. Ragweed stands provide shade, retard wind flow over the ground surface, and produce organic material, which, in the form of roots, helps stabilize the soil and, in the form of decay products, enriches the soil organically. Other species, unable to invade initially because of the physical rigorousness of the environment, may now become established. Thus perennial grasses, with their more extensive root systems and greater shade tolerance, can now thrive, and they do so at the expense of the pioneering ragweed. Whatever evolutionary talents ragweed has developed for colonization do not extend to persistence. Once environmental severity has been reduced, ragweed is unable to compete with other, less physically tolerant species for the limited space afforded in the field.

Nothing illustrates the evolutionary trade-off of adaptability to a rigorous environment at the cost of competitive ability better than work done on several weed species by Sheila C.A. Cook and coworkers at the University of

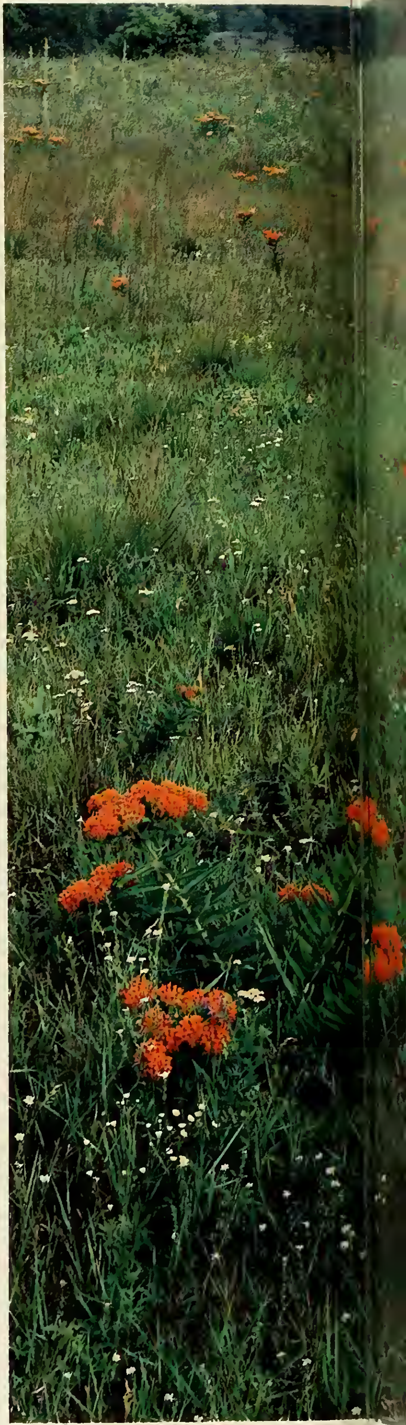
Robart P. Carr

*Queen Anne's lace*

Dwight R. Kuhn

*Ragweed*

Sylvia Johnson, Woodfin Camp and Associates


Robert P. Carr

Liverpool. Cook and her team of researchers studied two grass species and one herb that grow in North Wales on soils heavily contaminated from a zinc/lead mine. The grasses, *Agrostis tenuis* and *Anthoxanthum odoratum*, and the herb, *Plantago lanceolata* (English plantain), also grow abundantly on noncontaminated soils. Plants from contaminated and noncontaminated areas were grown together in noncontaminated soil to test the effects of competition. (Of course, a *Plantago* from a noncontaminated area could not grow in contaminated soil since it lacked the genetic ability to deal with the presence of the heavy metals.) In all cases, plants from noncontaminated soils easily outcompeted those from the zinc/lead soils. A *Plantago* from the area around the mine could not coexist with one from a noncontaminated area. In adapting to the extremely rigorous zinc/lead soil environment, the plant populations that succeeded had sacrificed some of their competitive abilities. They were really fugitive races existing only by virtue of their tolerance for an environment lethal to virtually all other species.

A similar situation exists in northern California as a result of the peculiar nature of the soil there. Soils derived from rocks high in magnesium iron silicate are termed serpentine soils. With poor supplies of essential nutrients and high concentrations of such potentially lethal heavy metals as nickel and chromium, the patchily distributed serpentine soils present colonizing plant species with severe environments. Nonetheless, serpentine races of weeds such as *Plantago erecta*, a common plantain species, occur regularly. When grown together with nonserpentine races of the same species in nonserpentine soil, serpentine races simply cannot compete. Apparently, the genetic reorganization required to produce a phenotype capable of living and reproducing in a harsh environment results in a dramatic change in the total pattern of development. Characteristics such as shade tolerance are no longer selected for since most disturbed environments are sunny and probably poorly vegetated. Indeed, the grasses that evolved tolerance to the zinc/lead mine soils were shorter than the plants from uncontaminated soils, which would put the tolerant plants at a disadvantage if they invaded uncontaminated areas. They would be overtopped and shaded out by their nontolerant relatives.

Some researchers believe that the genetic reorganization of developmental patterns required for adaptation to severe environments is of sufficient complexity to result in speciation. The zinc/lead mine soil grasses have evolved flowering times different from those of the nontolerant races. Also, the tolerant races are much more self-fertile than nontolerant populations. Both of these characteristics suggest the rapid evolution of reproductive isolation between tolerant and nontolerant populations.

For all their abilities to colonize harsh environments, weeds lack the competitive strengths to persist. Oaks, of course, lack the weeds' abilities to survive in extreme situations. Should an acorn actually sprout in a parched, sunny field it could indeed be "outcompeted" by the ragweed. However, when an acorn finds its way into a more moderate environment, its developmental pattern maximizes its chances of a long life. The oak tree devotes the lion's share of its energy to strengthening itself through the manufacture of extensive roots and branches, a thick, strong trunk, and myriads of leaves. Energy is used not merely to build but also to repair tissue. Chemicals such as tannins are produced, and these byproducts of the oak's biochemistry aid in discouraging insect attacks on its leaves. In addition, although the oak devotes far less of its energy toward reproduction than does lamb's-quarters, it has many more years to keep trying. Acorns may be heavy and short-lived, but only two need be successful for the population of oaks to remain unchanged.

Darwin, in the *Origin of Species*, recognized that more than one "strategy" exists for evolutionary success. Weeds and trees are good examples of ecological opposites. The weed puts

*Field of butterfly weeds and other wildflowers* most of its efforts into reproduction and dispersal. Each seed has a poor survival chance, so survival depends on large numbers being dispersed. The tree puts much of its energy into its own growth and competitive ability. Reproduction is moderate but continues over a long life span. Each acorn has more energy to begin with than does any weed seed and each acorn consequently has a better chance of survival.

The life history characteristics of weed species largely account for the abundant representation of European weed species in North America. Ecologists now characterize as "fugitive species" those weeds that succeed by skipping from place to place, taking advantage of temporary ecological disturbance. Considering the abilities weeds possess for dispersal and colonization, we can understand why aggressive European species have succeeded in American fields. Conversely, a lack of these abilities acts as a barrier to range expansion. European plants characteristic of undisturbed ecosystems, such as a forest, are still mostly in Europe. They lack the adaptations for nomadism found in the weeds. In addition, even if a European forest species could invade North America, it would face enormous competition from well-adapted native species. An undisturbed, ecologically balanced forest is a more difficult system to penetrate than, for instance, a recently burned area. Forests are saturated with species, whereas fields, burns, or hurricane blowdowns offer opportunities for the fugitives.

To illustrate this point, I calculated the percentage of introduced, or alien, species present in the 2-year-old field, the 30-year-old field, and a 200+-year-old oak-hickory forest I studied in New Jersey. In the 2-year-old field, 51 percent of the plant species were alien as opposed to 13 percent in the 30-year-old field and only 6 percent in the forest.

The presence of an abundant weed flora, native and introduced, provides ample evidence for the assertion that forested ecosystems in North America have been subjected to frequent disturbances throughout history. The great hurricane of September 21, 1938, destroyed millions of square miles of New England's forests but was a real vitamin shot for weeds. It is important to realize that as weeds invade a newly disturbed area, they perform a vital function relative to the welfare of the trees that will succeed them. Weeds are the stabilizers, the ecological Red Cross that moves in and prevents further damage while simultaneously aiding in the recovery process. Throughout the northern and western United States, for example, there is a plant called fireweed (*Epilobium angustifolium*). Fireweed's name is descriptive since its wind-blown seeds move in following a forest fire, and the plant then prospers until shaded out by aspens and, eventually, spruces. Its root system aids greatly in minimizing erosion on the burned area as well as adding valuable organic matter to the damaged soil.

An even more dramatic example is the role of the pin cherry (*Prunus pennsylvanica*) in the recovery of northern hardwood forests following disturbance. Although not herbaceous, the pin cherry is really a woody weed since it requires bright sun and open space, grows rapidly, disperses well, and is easily outcompeted by shade-tolerant tree species. P.L. Marks of Cornell University and F.H. Bormann of Yale University studied the pin cherry as it grew in an experimental area in the Hubbard-Brook Forest in New Hampshire. Following clear-cutting, the soil experienced very heavy mineral loss as a result of erosion. The pin cherry was robust enough to populate the disturbed site, and within five years all mineral levels in the soil had significantly increased. The tree had stabilized and aided the recovery of the area's depleted soils, thereby insuring the future reoccupation of the site by hardwood forest.

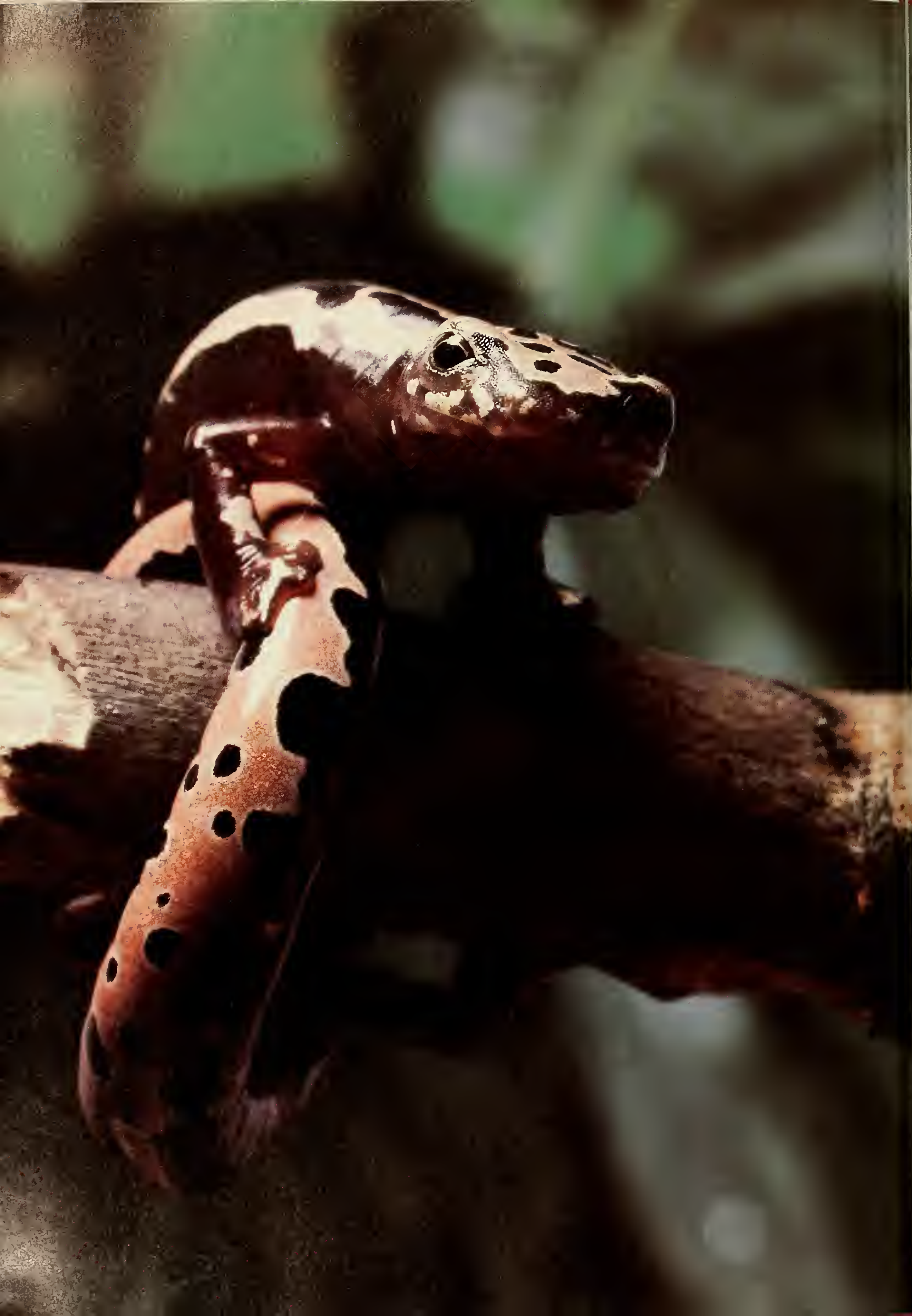
Weeds are magnificent organisms. They testify to the ability of life to cope with all environments. Weeds, in the most literal sense, "make hay while the sun shines." □

C. Postmus, Root Resources

*Wind-dispersed fireweed seeds*

*Grasses, milkweed, and young pines*

Robert P. Cerr



# Sala

*No longe*
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by James

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Raymond A.

# Salamander Invasion of the Tropics

*No longer restricted to aquatic habitats, lungless salamanders dispersed southward and achieved their greatest diversity*

**by James Hanken, James F. Lynch, and David B. Wake**

What is evolutionary success? Perhaps the most obvious example is an adaptive radiation: the divergence of members of a single lineage into a number of different ecological niches or adaptive roles. This divergence can involve changes of morphology, physiology, ecology, and behavior. By investigating adaptive radiations, we can learn the causes and limitations of evolutionary change.

In many ways, salamanders might seem unlikely subjects for the study of adaptive radiation. As is typical of most amphibians, salamanders must maintain a moist skin and are frequently restricted to aquatic sites in or near ponds, streams, and seepages or under moist logs or leaf litter in humid forests. Because salamanders are ectothermic (cold-blooded), their energetic needs are slight—usually only a fraction of those of birds and mammals. They can feed infrequently and remain inactive for long periods; this, plus their usually small size, makes them inconspicuous. For these reasons, some biologists have dismissed them as rare and of little ecological significance.

Despite their apparent low profile, in many habitats salamanders are the most abundant vertebrates. For example, salamanders in a New Hampshire forest were found to exceed birds and mammals in both numbers and biomass. Further, salamanders display a variety of body shapes and sizes, ranging from inch-long species to an Asian genus whose members attain lengths of five feet. Some salamanders are fully aquatic, others are partly so, and many are fully terrestrial. Most species have well-developed legs and feet, but some groups have tiny limbs, and others lack hind limbs entirely. Some salamanders are subterranean, while others spend their entire lives far above the ground in the canopy of tropical forests.

*One of many lungless salamanders of Central America is* Bolitoglossa mexicana, *native to Belize. Geologic events that fragmented populations helped to create a diversity of salamander species in this region.*

Reymond A. Mendez

The approximately 325 species of living salamanders are divided among nine families. However, more than 200 species belong to one family, the Plethodontidae, or lungless salamanders, and about 150 of these, or nearly half of all salamanders, are members of one subgroup, the tribe Bolitoglossini, or, literally translated from Greek, the "mushroom-tongued" salamanders. Salamanders as a group arose in the Northern Hemisphere, and virtually all living nonbolitoglossine salamanders are confined to the north temperate portions of Asia, Europe, and North America. In contrast, all but about a dozen bolitoglossines live at tropical latitudes in Middle and South America. How can we account for this successful invasion of the tropics?

The earliest lungless salamanders were descendants of stream-dwelling salamanders of the ancient Appalachian highlands of eastern North America. The most primitive living lungless salamanders are still found in stream habitats in the Appalachians where they maintain a 100-million-year-old life history pattern. Semiaquatic adults mate and deposit eggs at streamside. Carnivorous aquatic larvae that emerge from these eggs later metamorphose into terrestrially adapted adults that leave the water. This reproductive pattern, although typical of many other amphibians, constrains ecological and evolutionary diversification. Most important is the restriction of such amphibians to areas where aquatic breeding habitat is at least periodically available. Dependence on aquatic breeding sites also limits the ability of amphibians to disperse through areas without free surface water.

Exceptions to this life history pattern are rare in most salamander families. One alternative is demonstrated by a few species of the European genus *Salamandra*, in which females do not deposit eggs, but instead retain them in the oviduct where development proceeds. Young emerge either as well-developed aquatic larvae or fully metamorphosed terrestrial salamanders.

Many lungless salamanders, including all bolitoglossines, have evolved a different means of eliminating the restrictive aquatic larval stage. These salamanders retain the primitive pattern of laying eggs, but the eggs are deposited in moist, protected terrestrial sites where the female broods them for a long period (up to eight months in some species). At hatching, a fully functional salamander emerges, having achieved complete independence from aquatic habitats.

With this fully terrestrial reproductive mode, ancestral lungless salamanders dispersed across the humid temperate forests that covered most of North America during late Mesozoic and early Cenozoic times, ultimately extending west to the Pacific coast and south into the New World tropics. Subsequent episodes of mountain building and climatic change caused much of the temperate forest to disappear from the western half of North

America in favor of more arid habitats, eliminating lungless salamanders from virtually all of the mid-continental region and northern Mexico.

Today, isolated survivors of these events give us some idea of the enormous and nearly continuous distribution that lungless salamanders must have enjoyed in the past. Relict species still may be found in pockets of favorable humid habitat in New Mexico, Oklahoma, Texas, and Arkansas, while in California's Mojave Desert, several distinctive species have recently been discovered leading precarious lives around tiny springs and seepages in otherwise uninhabitable mountains. Most startling is the present distribution of the genus *Hydromantes,* one of the two genera of nontropical bolitoglossines. The western North American ancestors of *Hydromantes* dispersed into Asia via the Bering land bridge across the northern Pacific Ocean and extended their range to the west and south until they reached the Mediterranean region. Today, we find two of the five species of *Hydromantes* inhabiting caves and crevices in limestone areas of northern Italy, southern France, and the island of Sardinia, while the remaining three species are restricted to the mountains of central and northern California.

A great expanse of inhospitable arid country at present separates the lungless salamanders of temperate North America from those of the tropics. The northernmost members of the tropical assemblage include several generalized species of the genera *Pseudoeurycea* and *Chiropterotriton* that live at high elevations in Mexico's northern mountains. In morphology and ecology, these animals resemble the presumed ancestors of all tropical salamanders. These ancestral forms continued their southward invasion via mountainous dispersal routes, leaving descendants throughout all of Middle America and much of South America as far as Bolivia.

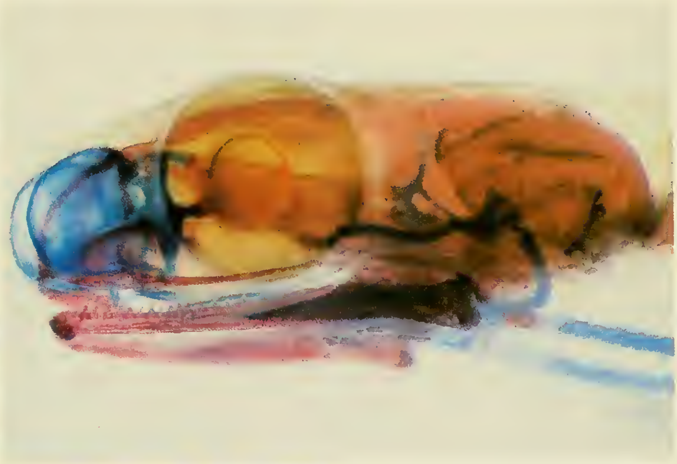
The adaptive radiation of salamanders in the tropics has produced more than 150 known species assigned to nine distinct genera. As many as sixteen species may inhabit a single tropical mountain. Salamanders in the tropics are perhaps most abundant in mountainous areas, but they also are well represented at intermediate and low elevations, with the proportion of lowland species increasing southward.

James Hanken

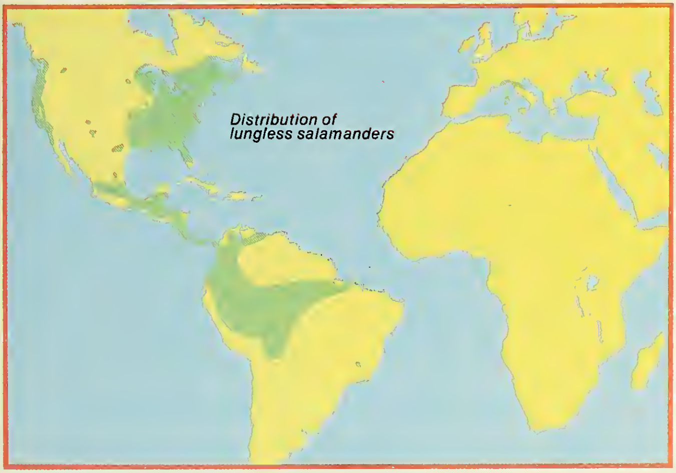
In southern Mexico and Guatemala more than 40 percent of the species are found, at least in part, below 5,000 feet and 14 percent occur below 1,500 feet. Farther south in Costa Rica, Panama, and northwestern South America, more than 85 percent of the species occur below 5,000 feet, and fully a third of the species live below 1,500 feet.

This information will help dispel the belief that tropical salamanders are restricted to high, mountainous areas with climates and habitats similar to cool, temperate forests. Salamanders are both diverse and locally common in the lowland forest where they thrive in conditions that are, by anyone's standards, truly tropical. Temperatures are characteristically high and rainfall may be highly seasonal, limiting activity by salamanders to only a portion of the year.

Although ecologists argue over the causes and effects of tropical diversity, a given tropical habitat will generally have more predators, parasites, and competitors than a corresponding temperate habitat. By conducting field studies we have attempted to understand how tropical salamanders have not only managed to invade tropical communities but to flourish in them. One important aspect concerns community structure. In North America, coexistence of similar species is achieved by a number of mechanisms. For example, in salamander-rich areas of the Appalachians, the species in a local community are about equally divided between aquatic and terrestrial forms. In species with aquatic



James Hanken

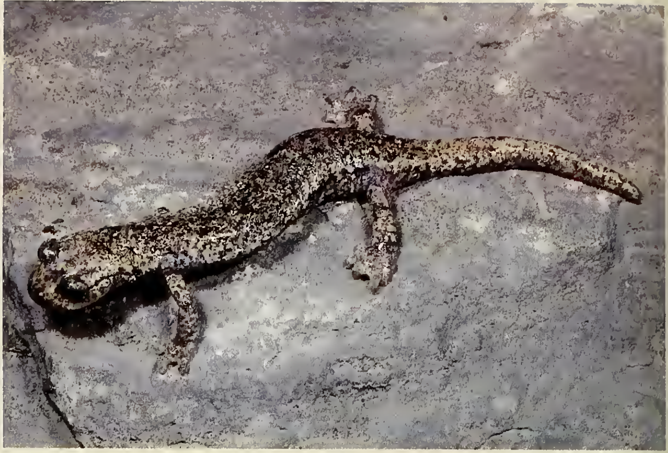


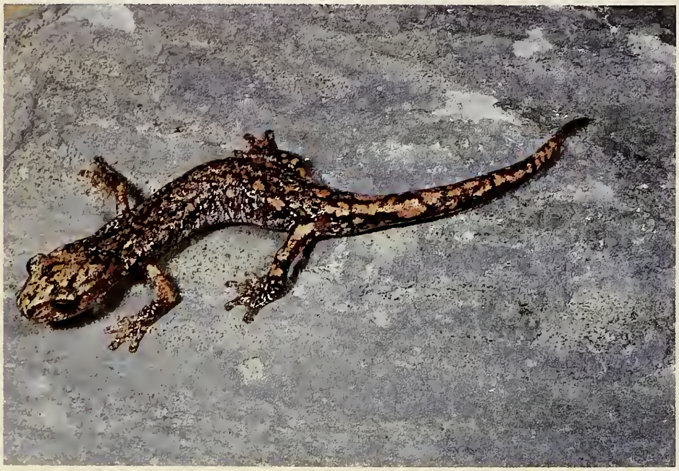
Bob Ritter

*In ten milliseconds the salamander* Bolitoglossa adspersa, *above left, found in Colombia, can fire its tongue a third the length of its body, capture an insect, and return the prey to its mouth. The long tongue makes it largely unnecessary for bolitoglossine salamanders to pursue prey. The photomicrograph, above, shows an artificially colored specimen of the smallest, tailed tetrapod species,* Thorius pennatulus. *Behind the large eye characteristic of small tropical salamanders is the otic capsule (dark red), the structure that controls balance and hearing.*

photographs by James Hanken

*These two salamanders,* Hydromantes platycephalus *from Sonora Pass, California, right, and* H. italicus *from Liguria, Italy, below, belong to a genus with a remarkably disjunct distribution. The North American ancestors of* Hydromantes *dispersed into Asia, eventually reaching the Mediterranean. Mountain-building processes and climatic changes eliminated the habitat of the lungless salamanders so that only five species of* Hydromantes *are found today. Relict populations of two of the present species persist in caves and rock crevices in northern Italy, southern France, and Sardinia. The other three species survive in the mountains of central and northern California.*





reproduction, larval development may occur in springs, streams, or ponds, and breeding seasons may differ from species to species. Thus, both spatial and temporal overlap of larvae and, presumably, larval competition are reduced. Species that occur in the same habitat at the same time frequently differ in body size, and this is correlated with differences in the kinds and size of animal prey taken. All of these mechanisms may reduce competition between coexisting species.

Tropical salamander communities are different. As we have noted, all tropical salamanders are fully terrestrial, so separation along an aquatic-terrestrial gradient is not possible. Instead, two types of vertical segregation are especially important.

First, each tropical species has a narrow, precisely defined altitudinal distribution that frequently matches the complex, yet regular, elevational zonation of tropical plant communities. In this way, species present on the same mountain may actually never occur together because of nonoverlapping elevational distributions. Although altitudinal layering also occurs in temperate regions, it is never as pronounced as in tropical habitats.

At any given elevation and habitat, further sorting is achieved by different species living at different heights above or below the forest floor. Some burrow, others confine their activity to the ground surface, while many literally take to the trees where epiphytic plants, especially bromeliads, are favored retreats. Lacking a functional root system, bromeliads attach themselves to the trunks and limbs of trees and obtain necessary moisture and nutrients from the atmosphere. Like salamanders, bromeliads thrive in areas with excessive humidity, particularly the cool, fogbound cloud forest that cloaks the slopes of many tropical mountains. There, a diverse community of salamanders and other small animals has evolved in the aerial swamp created by the upward-directed, tightly overlapping leaves of bromeliads. The association between salamanders and bromeliads is hardly casual. Some salamander species occur nowhere else, and local densities can be great—as many as thirty-four salamanders have been found inside a single bromeliad in a Mexican cloud forest. We have found salamanders in bromeliads as high in trees as we have been able to search, and examination of recently felled trees (an all-too-common sight in the tropics) has revealed salamanders at least 100 feet above the ground.

Distinctive habits and habitat preferences of salamanders are often associated with morphological specialization, and several species, or even whole genera, are highly modified to survive in tropical environments. Arboreal montane species usually have small, flattened bodies that allow them to squeeze between tightly overlapping bromeliad leaves. Such species also possess a moderately prehensile tail and partially webbed hands and feet that adhere readily to wet leaf surfaces, providing great climbing ability. Burrowing forms have tiny limbs and extremely elongate bodies

*The evolution of a terrestrial life style preadapted bolitoglossine salamanders for survival in rugged tropical areas where free-standing water is scarce.*

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and tails that almost make them vertebrate worms. Members of the genera *Thorius* and *Parvimolge* are true miniatures. Living among leaf litter and bark on the forest floor, some adults may be only one inch in total length. This brings them very near the minimum size limit for vertebrates, and they possess various skeletal and sensory modifications to accommodate their reduced size.

The most specialized of all tropical salamanders live in the wet lowland forest. During the day most species conceal themselves in bark crevices, leaf axils, or other relatively inaccessible sites. Emerging only at night, they cling to a tree trunk, plant stem, or leaf surface in wait of prey. (This behavior explains why even experienced field biologists have tended to overlook lowland tropical salamanders.) Ground-dwelling salamanders are scarce in the lowland tropics; almost all lowland species are either arboreal or subterranean. Arboreal lowland salamanders are even more highly specialized than their relatives in the montane cloud forest. A fully prehensile tail and extensive webbing, which in effect turns the hands and feet into suction cups, allow a salamander to suspend itself, even upside down, from stems and leaves.

During the evolution of tropical salamanders, a premium has been placed on adaptations that reduce activity and make the most of available energy. A prime example involves prey capture. Most nontropical lungless salamanders ingest insects, millipedes, and snails by partially flipping out a sticky tongue, then retrieving it with the prey item attached. Simultaneously, the salamander may lunge forward and seize its victim in its jaws, especially when the prey is large. Because the front of the tongue is anchored to the lower jaw, the back of the tongue is flipped out at the prey. This resembles the movement of a clenched fist resting palm up on a table top as the fingers are first quickly outstretched and then reclenched. The anterior attachment of the tongue means that prey can be attacked only at close range.

*Extensive webbing on the feet of this specialized species,* Bolitoglossa mexicana, *creates a suction cup effect, enabling the salamander to suspend itself from stems and leaves.*

Raymond A Mendez

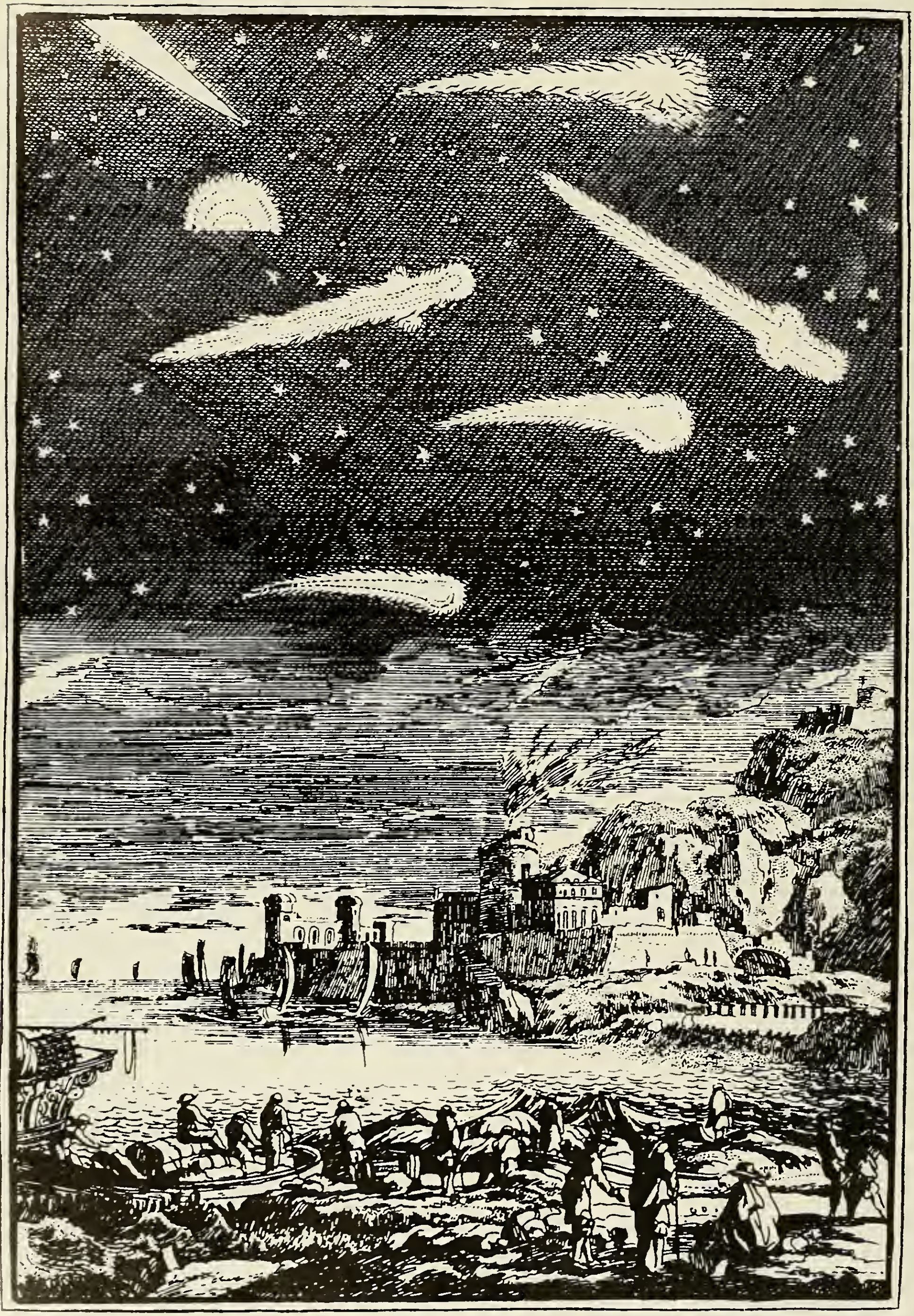
In contrast to this primitive pattern, the tropical salamanders have evolved a highly protrusible tongue that can be fired accurately for long distances at astonishingly high speeds. Careful laboratory measurements have shown that in the genus *Bolitoglossa* the tongue can be extended to about a third of a salamander's body length and returned to the mouth with a captured prey in as few as ten milliseconds. The evolution of this efficient prey-capturing system has required a complete reorganization of the musculature and skeleton of the tongue to allow the mushroom-shaped tongue, now no longer attached in front, to be catapulted from the mouth. As an additional refinement, bolitoglossines have developed the ability to control the direction of tongue projection. Thus, the salamander need not directly face or actively pursue its prey. A highly modified tongue structure means that a salamander can instead wait for prey to approach within its increased firing range.

Regional species diversity of tropical salamanders is greatest in areas that are geologically most active. To fully understand the regional patterns of adaptation and diversity in salamanders, we must consider geologic factors as well as behavior and morphology. Throughout much of Middle and South America large-scale tectonic processes, ranging from massive volcanic activity to lateral slippage of continental plates, have created new habitat, destroyed previously habitable areas, erected barriers to dispersal, and fragmented once continuous salamander distributions.

A particularly good example of the connection between geologic events and biotic diversity and distribution is seen in the genus *Chiropterotriton.* Eight species of this group are found in wet montane forests of Guatemala and adjacent Mexico and Honduras. Morphological, genetic, and ecological evidence agree that these species are more closely related to one another than to any other salamanders, insofar as they share a common ancestor. Each species is confined to its own mountain range or cluster of ranges, and no two species occur together. For tens of millions of years, this part of northern Central America has been the scene of violent geologic activity. The region straddles the juncture of three major crustal plates, and massive fault scarps crisscross a landscape dotted with some of the most spectacular volcanoes on earth. Originally continuous upland areas, some of which date from the early Cenozoic period, have been repeatedly fragmented by lateral faults, and large upland sections have been moved hundreds of miles from their original locations. Any ancestral *Chiropterotriton* species that inhabited the continuous upland habitat would have been fragmented into numerous subpopulations, each separated by impassible lowland barriers. Some of these isolated populations doubtless went extinct, but others continued to evolve independently, so that now each is sufficiently differentiated to qualify as a distinct species.

Why have salamanders experienced such a major adaptive radiation in the tropics? We can suggest the following explanations: (1) The prior evolution of a fully terrestrial life history preadapted bolitoglossine salamanders for life in the tropics, particularly in rugged, mountainous areas where free surface water is scarce, (2) limited activity, slow metabolism, and a simple, yet efficient, feeding mechanism allow salamanders to make slight energetic demands on an environment and invade and occupy otherwise closed tropical communities, (3) morphological specializations, including a diversity of locomotor patterns, (4) the availability of distinctly tropical microhabitats, especially arboreal bromeliads, enables more species to be packed into a given habitat, (5) restriction of species distributions to the narrow elevational zones of climate and vegetation characteristic of tropical environments increases local diversity, and (6) the extraordinarily high intensity of geologic activity in Middle America and northern South America has promoted the formation of new species, thereby increasing regional diversity.

Tropical salamanders provide an unusually favorable opportunity to study patterns of evolution. Our effort has spanned more than a decade, and has at various times included the collaboration of anatomists, physiologists, taxonomists, ecologists, biochemists, and geneticists. It is sad to note that thoughtless devastation of fragile tropical habitats by humans threatens to obliterate many of the most interesting pages of this story before they can be read. ☐



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# The Comet Syndrome

*Human reactions to encounters of the cometary kind range from hysteria to frivolity*

**by Michael Oppenheimer and Leonie Haimson**

Comets have always been news, usually of the bad variety. Throughout history their spectacular arrival has provoked astonishment, consternation, and frequently, a sense of foreboding among observers. With Halley's comet due to reappear in 1985 and a space mission to a comet planned for the 1980s, it is worthwhile to recollect former attitudes toward comets.

Traditionally, people believed that comets presaged death in the form of wars, epidemics, or natural disasters. Aristotle pointed out that a comet appeared at the time of an earthquake and a subsequent tidal wave that swallowed the cities of Helice and Bura in the Peloponnesus, and in Biblical times it was commonly thought that the arrival of a comet accompanied the destruction of Sodom and Gomorrah.

Seneca wrote that "when one of these fiery bodies . . . appears . . . [men] know not whether to wonder or to tremble; for many spread fear on all sides, drawing from the phenomenon most grave prognostics."

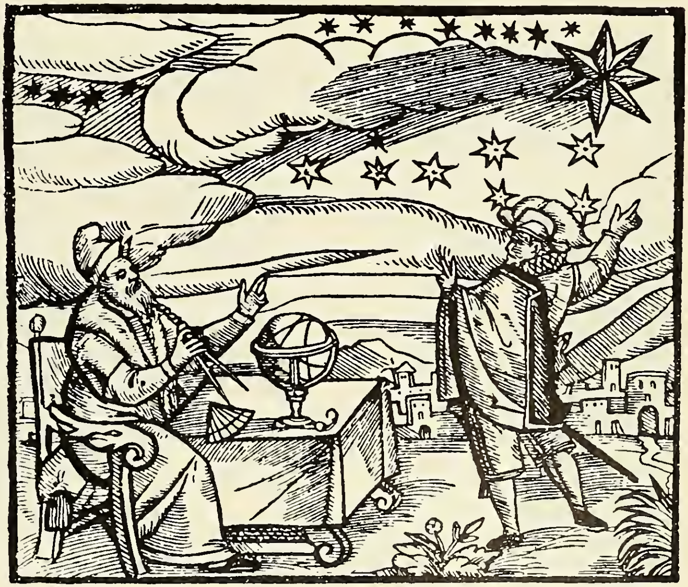
Most often, comets were interpreted as predicting the imminent demise of a prominent leader. Shakespeare echoed this belief in *Julius Caesar:* "When beggars die, there are no comets seen; The heavens themselves blaze forth the deaths of princes." Among the rulers whose deaths are known to have been marked by comets were Attila, the Roman emperor Valerian, and Julius Caesar himself.

Every plague and pestilence in the Middle Ages was supposedly connected with the materialization of a comet, and even if one did *not* show up when something untoward occurred (as with the death of Charlemagne), chroniclers noted their appearance nevertheless. When the year 1000 approached, the date itself convinced many that the end of the world was impending, and the sight of a genuine comet only exacerbated the general terror.

In the non-Western world, comets were also perceived as potential threats. In Japan, each time a comet appeared the reigning emperor summoned monks to his court to perform an exorcism rite and, for reasons that are obscure to us, he would prohibit the slaughtering of animals until the comet passed out of view. One emperor abdicated when confronted with the sight of a comet.

Several comets observed by the Aztecs in the late fifteenth century led them to believe that the end of the world and the return of their god Quetzalcoatl were imminent. To their profound regret, this encouraged them

*A French engraving, facing page, shows different kinds of comets that reminded the seventeenth-century artist of other objects. The fanciful version of a comet, below, adorned the title page of a late-sixteenth-century manuscript.*



The Granger Collection

to accept Cortés and his men with a mixture of resignation and awe when the invaders arrived in 1519.

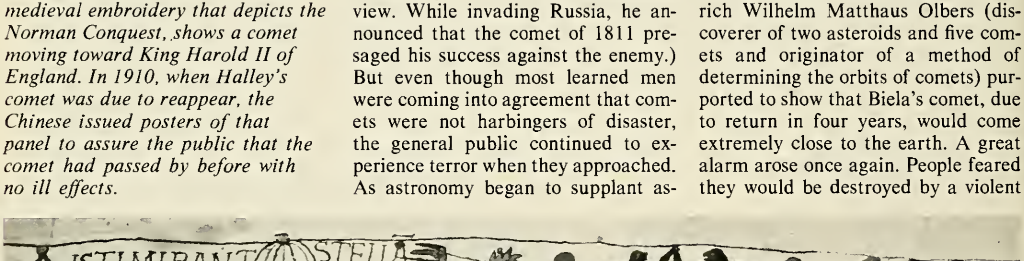
One of most intense and widespread of comet scares arose in 1528. A French surgeon reported that a comet materializing in the skies that year "was so horrible and so frightful and produced such great terror in the vulgar that some died of fear and others fell sick." Various observers thought the comet looked like the "figure of a bent arm, holding in its hand a great sword, as if about to strike." This account is reminiscent of a reference in the Bible that some have taken to be a description of an ancient comet: "And David lifted up his eyes, and saw the angel of the Lord stand between the Earth and the Heaven, having a drawn sword in his hand stretched out over Jerusalem" (I Chron. 21:16).

By the seventeenth century, however, the belief that comets were necessarily evil omens was slowly beginning to be questioned by both scientists and the clergy. (Much later, Napoleon, whose own birth was marked by a comet, took the opposite view. While invading Russia, he announced that the comet of 1811 presaged his success against the enemy.) But even though most learned men were coming into agreement that comets were not harbingers of disaster, the general public continued to experience terror when they approached. As astronomy began to supplant astrology and the populace became convinced that a comet was simply a celestial object that moved past us, a new fear replaced the old one—that a comet would hit the earth. In 1758, John Wesley used the return of Halley's comet to preach the necessity of being right with God. "Were it to fix upon the earth . . . when it is some one thousand times hotter than a red-hot cannon ball, who does not see what must be the immediate consequence?" he asked.

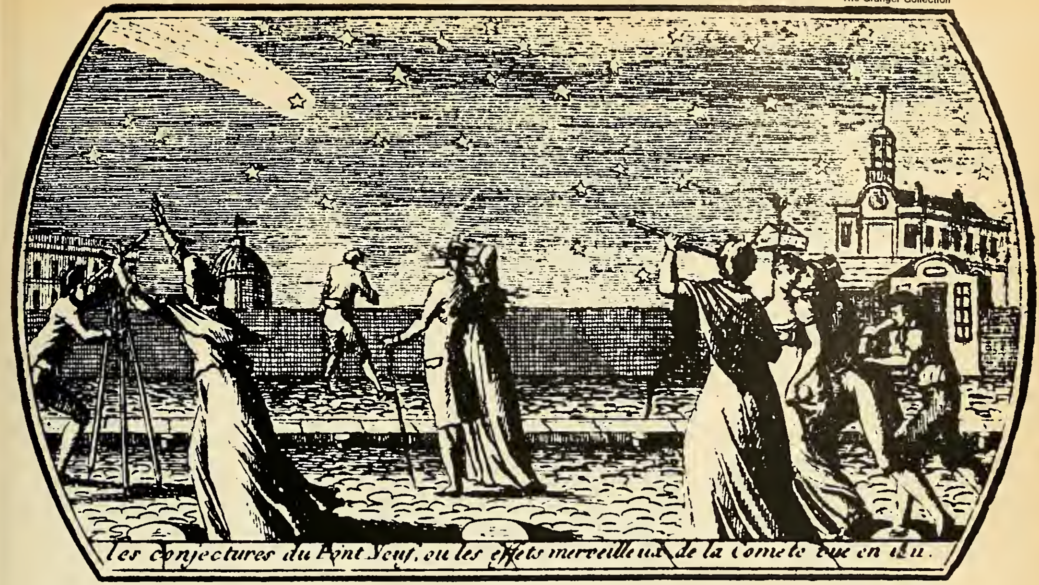
In 1773, everyone in Paris began to talk about an upcoming lecture by the mathematician and astronomer Joseph-Jérôme Le Français de Lalande, entitled "Reflections on Those Comets Which Can Approach the Earth." The rumor spread that on May 20 a comet would destroy the earth, although Lalande publicly denied it. According to a contemporary French professor, "places in Paradise were sold at a very high rate," and people begged the Archbishop of Paris to pray to God to alter the comet's course.

The situation was repeated in 1828. Certain calculations published that year by the German astronomer Heinrich Wilhelm Matthaus Olbers (discoverer of two asteroids and five comets and originator of a method of determining the orbits of comets) purported to show that Biela's comet, due to return in four years, would come extremely close to the earth. A great alarm arose once again. People feared they would be destroyed by a violent

*One panel of the Bayeux Tapestry, a medieval embroidery that depicts the Norman Conquest, shows a comet moving toward King Harold II of England. In 1910, when Halley's comet was due to reappear, the Chinese issued posters of that panel to assure the public that the comet had passed by before with no ill effects.*



By authorization of the City of Bayeux


Les conjectures du Pont Neuf, ou les effets merveilleux de la Comete vue en l'air.

The Granger Collection

Epatant! *The comet of 1812 as it might have been viewed from the Pont Neuf in Paris.*

terrestrial shock or drowned in a universal deluge. The hysteria did not subside until *Tract on Comets* was published by Dominique François Arago, a French astronomer noted for his observations. It demonstrated conclusively that Biela's comet would come no nearer the earth than fifty million miles.

In the same book, Arago disputed various, commonly held misconceptions about comets. First of all, he argued against the prevailing theory that comets affected the weather, a belief that supposedly accounted for the superiority of wines made in the years during which comets passed by. One vintage year, for example, was noted for producing the "comet wine" of 1811. Comets were believed to cause higher temperatures and thus higher sugar content in the grapes from which wines were made. Arago showed, however, that the average temperature of comet years was no higher than normal. Even so, wine catalogs until the end of the nineteenth century continued to refer to the "comet wine" of 1811.

Arago also took issue in his treatise with the *Atmospheric Causes of Epidemic Diseases*, a popular work written in 1829, which claimed that "ever since the Christian era, the most unhealthy periods are precisely those in which some great comet has appeared." It further contended that such occurrences as earthquakes, fogs, and volcanic eruptions were linked with the effects of comets. Arago's protestations, however, provided only temporary comfort, and comets continued to be regarded with awe and terror down to the twentieth century.

Despite their generally baneful aura, comets have undeniably benefited one select group—their discoverers. Traditionally, comets are named for their discoverers; that small measure of immortality is often the greatest incentive for their search. Many astronomers throughout history have enhanced their reputations by being the first to sight a comet. Charles Messier, the eighteenth-century French astronomer known for his catalog of nebulae and star clusters, comes to mind. He discovered at least fifteen comets during his lifetime and thereby won recognition from King Louis XV who called him the "comet ferret."

Not all comets, however, are discovered by professional astronomers or dedicated comet hunters. Ordinary people have sometimes been first, often by accident. In 1861 an Australian sheep farmer discovered a comet. In 1910, a group of miners and railway workers spotted a new comet while walking home early one morning after their shift. More recently, in 1961, a comet was simultaneously discovered by a professional astronomer, a pilot, and an airline stewardess. And

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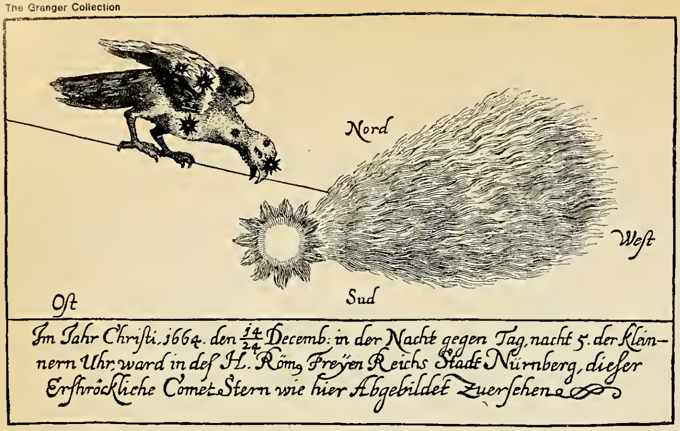

Nord
Weſt
Oſt
Sud
Im Jahr Chriſti.1664. den 14/24 Decemb: in der Nacht gegen Tag, nacht 5. der kleinnern Uhr, ward in deß H. Röm, Freyen Reichs Stadt Nürnberg, dieſer Erſchröckliche Comet-Stern wie hier Abgebildet zuerſehen.

*Surprise meeting between a bird and a real comet in the year 1664, from a contemporary German engraving.*

not all astronomers have eagerly sought the fame that comet discovery tends to bring with it. Maria Mitchell, a young astronomer who lived on Nantucket Island, noticed a comet one night in 1847. At first she resisted her father's counsel to report the sighting to the director of the Harvard Observatory, but after much argument, she was persuaded to allow the sighting to be reported. She had, in fact, detected a new comet for which she eventually received the medal the King of Denmark awards annually to the discoverer of an important comet. Her reputation greatly enhanced, Mitchell subsequently became the first and until 1943 the only woman elected to the American Academy of Arts and Sciences in Boston. In 1865, she accepted a position at Vassar, where she had the use of the third largest telescope in the country, and she soon became celebrated for her brilliance as a teacher and a scientist. (For more on Maria Mitchell see "Women Astronomers" in the May 1979 *Natural History*.)

In recent years, the Japanese have dominated the discovery of comets. In 1959, Kaoru Ikeya, a young lathe operator who earned $28 a month, determined to redeem his family name from the disgrace of a father fallen into bankruptcy and alcoholism. For two years Ikeya ceaselessly worked on a telescope, grinding his own lens, and then for sixteen more months, he scanned the night sky. (This was a man whose personnel records listed him as lacking ambition and initiative.) Finally, on January 2, 1963, when he was nineteen, Ikeya's diligence was rewarded. He sighted a new comet, became a hero in Japan, and even played himself in a film based on his life. His hometown so appreciated his accomplishments that it converted an abandoned water tower, at public expense, to an observation dome for his personal use. Eventually, Ikeya discovered two more comets.

Ironically, Halley's comet—the most famous comet of all—which has been reappearing since antiquity, is not named for the individual who sighted it first (no one knows who that was). Halley's is the brightest comet that returns periodically into our view at relatively short intervals, approximately every seventy-five years. Throughout history it has been associated with a variety of pivotal events. Extrapolation indicates that in A.D. 66 it appeared while Jerusalem was under siege by the Romans, and one century later, it preceded by only a few months the Norman Conquest of England. In fact, in one of its panels the renowned Bayeux Tapestry, which chronicles the Norman Conquest, depicts a comet moving toward King Harold II of England. Then in 1456 when the Turks were attacking Belgrade, the comet again appeared, frightening both armies and causing Pope Calixtus III to call for special prayers so that the Christians might be spared disaster.

The periodicity of comets, however, was not established until the late seventeenth century. Newton observed the movements of a comet in 1680; two years later he studied another comet and attempted to describe its orbit mathematically. Edmond Halley, a young and gifted astronomer, visited Newton in 1684, and found that he had completed work on a theory of gravitation that, if valid, demonstrated that bodies mutually attracted would tend to move in elliptical, parabolic, or hyperbolic orbits. Halley convinced Newton to publish his results, and because the Royal Society of London lacked sufficient funds, Halley himself financed the printing of the work known as *Principia*.

For the next twenty years, Halley's energies were employed elsewhere, primarily in the study of navigation. Not until he was appointed to a chair at Oxford in 1704 did he return to the study of cometary movements. Applying the theories set out in *Principia*, he began to compute the orbit of the comet observed in 1682, and some twenty-four others. After long and careful work, Halley was surprised to discover that some of the orbits were elliptical; theoretically, therefore, comets with those orbits would return. More specifically, the orbit of the 1682 comet closely resembled the orbits of the comets of 1531 and 1607. When Halley referred to historical records, he found that various comets in earlier times could have been sightings of this same object as well and he estimated its period at seventy-six years. Finally, Halley extrapolated that this comet would reappear at Christmastime in 1758. Unfortunately, he died sixteen years before the comet was due to reappear. His reputation at his death was greatly enhanced by his work but not absolutely assured.

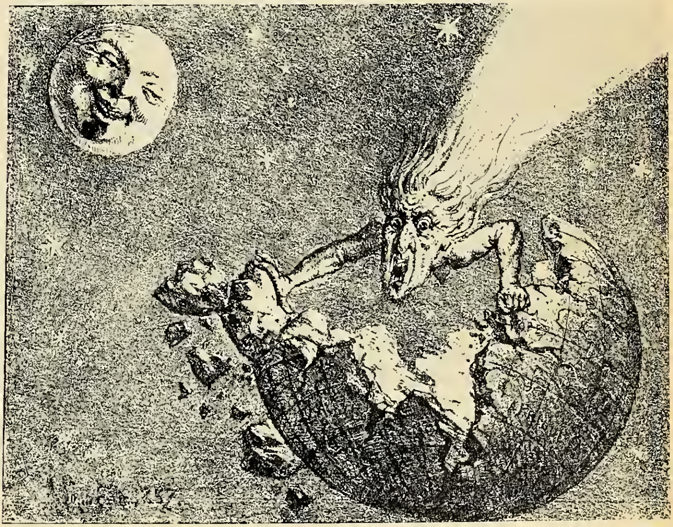
When the year 1758 rolled around, all the astronomers in Europe were eagerly, almost obsessively, scanning the skies. (According to Voltaire, no astronomer slept that year.) All the prominent comet hunters, including Messier, were involved in the search, yet the first to spot the comet—and to provide a significant confirmation of the general validity of Newton's theory of gravitation—was an amateur, a German farmer named Palitzch, who found the comet on Christmas night using a homemade seven-foot telescope. Halley was acclaimed when from that time on, by common consent, the comet was named for him.

When Halley's comet next returned in 1835, Mennonites in America, reportedly believing it foreshadowed the end of the world, allowed their crops to die on the vine. Many others were similarly fearful. A woman who lived in upstate New York and was twelve years old at the time remembered that "people were scared as wild geese. . . . We took out our sleds for a moonlight coast downhill. But we came right in. The snow was red as blood from the comet's glare—we didn't dare even to step on it."

Halley's comet approached the earth again in 1910, but this time the planet was due to pass through or very near the comet's tail. This had occurred with another comet in 1861, without any apparent ill effects, a fact with which the experts attempted to reassure the public. Yet as the year began, astronomers at Yerkes Observatory in Wisconsin made a possibly disturbing discovery. From spectral analyses, they determined that there was poisonous cyanogen gas in the comet's tail. According to a contemporary article in the *New York Times*, one of the scientists was "of the opinion that the cyanogen gas would impregnate the atmosphere and possibly snuff out all life on the planet." Most other astronomers disagreed, but a widespread feeling of foreboding remained, and when the comet was first sighted by eye in Curaçao on April 20, there were reports of alarm all over the world. From Rome to Mexico, people suffered great anxiety. In Chicago, a premature scare was set off on April 23, even before the comet came over the United States, when sudden darkness caused by weather conditions descended on the city for two hours. The phenomenon was gratuitously attributed to Halley's comet and some people became hysterical.

Nevertheless, as the comet came into view over the United States, feelings of excitement and exhilaration began to grow. The sales of telescopes increased sharply, and wholesale dealers reported that their supplies were exhausted. More telescopes were reputedly sold in the three months before the comet's arrival than in the entire period following the Civil War. According to the *Times*, the purchasers were drawn from all "classes," and they usually bought expensive instruments, "first-class telescopes that sell from $50 to $250. Many of the buyers set up their telescopes on the roofs of their apartments or houses, and on April 23 one of them received an un-

*A mid-nineteenth century French newspaper cartoon of what would happen if a comet collided with the earth.*



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anticipated bonus when, observing at night, he spotted a burglar trying to break into his brother's apartment.

Along with telescope sales, rumors also flourished as the comet approached. One was that when the tail passed through the earth's atmosphere, all the nitrogen would be converted to nitrous oxide, or laughing gas, and the world's inhabitants would cavort, transported, until they died. Another was that the comet might strike the earth's North Pole, displacing all electrical currents, and electrocuting everyone. Even some reputable scientists claimed that recent torrential rains in Europe were somehow related to cometary influence.

Astronomers, several of whom had certainly contributed unnecessarily to the widespread panic, were outraged that they were being blamed for withholding the full story. Thousands of accusatory letters about the comet flooded the Harvard Observatory. One professor complained that the letter writers "seem to think we are responsible for it."

Consternation spread all over the world. In Johannesburg, some enterprising men bricked up a room, installed cylinders of oxygen, and advertised in the local newspaper for "others who would share the expenses. . . . Numbers strictly limited." The wife of a prominent South African mine owner took up residence in a special chamber constructed at the bottom of one of her husband's mines. Chinese authorities issued posters of the Bayeux Tapestry to allay the general fear by showing that the comet had passed by before without harmful effects. In the American South, churches were packed and the fields were practically empty of hands. Many people sealed the doors and windows of their homes to keep from being poisoned and there were numerous stories of suicides and sudden breakdowns. "Comet pills" to counteract possible harmful effects were sold in the streets of Haiti, and according to one report, even in the United States. Mexicans gathered around crucifixes erected in the hills or sought refuge in caves and canyons.

Other, more sophisticated places had their own characteristic ways of celebrating the approach of the comet. The French seem not to have taken the whole affair as seriously as they had in previous eras. In Paris, special "comet suppers" were held at all the big cafes and restaurants. For days preceding the event, hawkers on the street offered postcards illustrating the presumed "end of the world," while "brooches and other pieces of jewelry representing the comet and its tail are sold in great numbers."

In New York, excitement built steadily. A new drink, "the comet cocktail," was invented at the Plaza Hotel and immediately became popular. The ingredients were kept secret, but its imbibers found that "it started with a fiery taste," followed "by a soothing sensation to the palate, and a general feeling of mental buoyancy." As in Paris, fashionable New Yorkers arranged private parties on the roofs of all the large hotels. At one particular gathering, a late-night dinner on top of the Gotham Hotel, the guests arrived in their motorcar togs and were supplied with small silver telescopes as favors.

Despite some urban festivities, certain ancient superstitions did persist. In Bermuda, for example, according to the *Times*, at the moment of the accession of King George V, "a sudden flaring up at the end of the comet's tail" was observed, leading many to expect a calamitous war would break out at some time during George's reign. (Five years later, when World War I was raging, a comet seen by the British on the Western Front was thought by them to herald tremendous casualties for their side, and seemed to them to be an "ally of the Central Powers.")

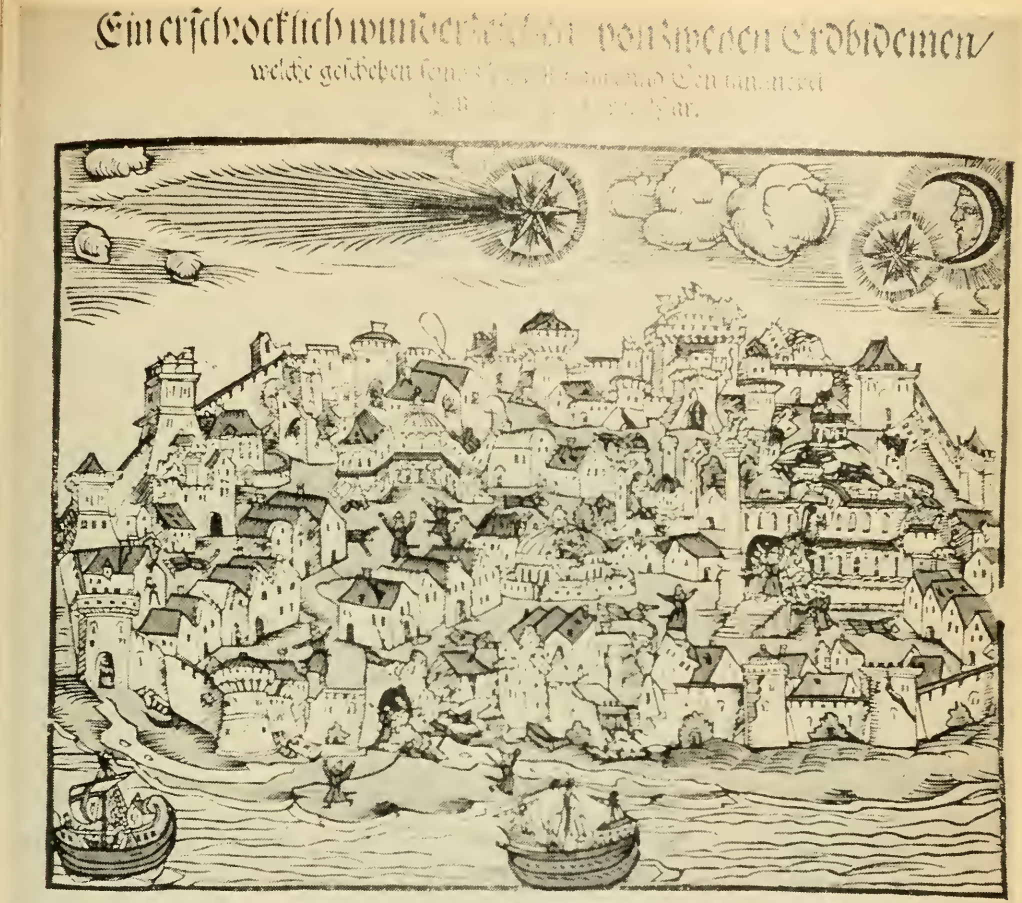
When the earth finally did pass through the comet's tail on May 18, 1910, a few auroralike flashes of light were observed, but that was all. There were no signs of cyanogen or laughing gas or electrical irregularities. At its height, however, the comet presented a spectacular appearance, displaying a tail that covered about one-tenth of the arc of the night sky. The *New York Times* concluded that on balance the experience was probably beneficial: "Superstition has received another blow, general interest in astronomy has been excited, and everybody has learned at least a little something about the heavenly bodies and their motions." But perhaps the most appropriate headline was the final one on May 26, "Pope NOT Impressed with Halley's Comet. Remarks On Viewing It That It Does Not Seem to Justify Commotion It Has Caused."

Comparatively few comets in history have been observable without a telescope. Of the approximately three hundred comets discovered in the nineteenth century, only thirteen were visible to the naked eye. Even fewer have been observable in daylight. Comet Ikeya Seki of the fall of 1965 (discovered by the same Ikeya already mentioned) was the only comet since the 1910 appearance of Halley's that was bright enough. Unfortunately, it was not widely seen in the northeast United States because of adverse weather conditions and because it appeared very early in morning.

The anticlimax provided by Comet Kohoutek is assuredly well remembered. Headlines appearing in various magazines in late 1973 and early 1974 chronicle the story. "Bright Comet May Light the Skies of Christmas" in April. "Bright Comet Next Winter" in May. "Comet of the Century" and "Get Set For the Sky Spectacular of the Century" in November. And, finally, "Flop of the Century?" and "Kohoutek the Tiny" in January. The cause of the dashed hopes was that Comet Kohoutek was relatively bright only while at a great distance from the earth, when it blew off volatile material as it approached the sun for the first time and heated up. After that mantle had dissipated, the comet's brightness returned to more average levels and the initial predictions of a spectacular sight proved premature.

Halley's comet, which will return in 1985, may also be a disappointment. Because of its position and that of the earth and sun, the comet will appear relatively faint to us when it should be at its brightest, after it passes the sun. But other comets will doubtless appear and may perhaps be seen trailing across the sky even by those not interested in astronomy or telescopes. If such a visitor from space should come by, be forewarned. Even now the sight of a comet may induce a sense of awe and perhaps bring a subtle twinge of fear to those who witness it. ☐

*Double trouble in mid-1550s Constantinople. A comet passed over the city and parts of the Hagia Sophia mosque crumbled in an earthquake. To the artist who decorated this German-language broadside, there may have been a connection.*



Ein erſchrocklich wunder[illegible] von zweyen Erdbidemen/
welche geſchehen ſeind [illegible]
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# Museum Menagerie

One tends to think of the American Museum of Natural History as a repository of bones, skins, fossils, and other relics of life. One would be startled to see a chimpanzee pedaling a kiddie car through the halls, for example, or a ferret riding an elevator.

The Museum, it turns out, has always been home to many eccentric living animals. As dusk gathers over the Museum, bats swoop down from the eaves and fly about looking for

*Alice Gray holding Blondie*

AMNH

# merican Museum

insects. In the Museum's rooftop greenhouse, cockroaches with numbers taped to their backs creep out of their hiding places. Hoping for a tasty mouse, a nine-inch toad from Surinam begins its nightly perambulations in the Department of Herpetology. Some Museum animals, such as the bats, are wild, while others are either participants in scientific research or the pets of staff members.

One of the most celebrated "pet" collections belongs to Museum entomologist Alice Gray. Gray and her menagerie, which includes scorpions, tarantulas, centipedes, cockroaches, and millipedes, have made television appearances on "To Tell the Truth," "What's My Line?" and the "Mike Douglas Show."

Scattered about in Gray's large and cluttered office are mayonnaise jars, glass cages, and plastic boxes crawling with exotic creatures. One of her favorites is the four-inch Madagascar hissing cockroach, the sight of which would make any apartment dweller grateful for his relatively tiny roaches. When disturbed, the Madagascar roach issues a loud, evil-sounding hiss by drawing air through spiracules in its chitinous shell. (Incidentally, it also uses these spiracules when molting; by sucking air through them, it bursts its skin down the back.) Cockroach enthusiasts are delighted to find numerous other species in Gray's collection, including Oriental, German, American, Australian, and green Cuban roaches, "giant" roaches and lobster roaches in cages along one wall.

The grande dame of Gray's tarantula collection is Blondie, who was raised from infancy in the Museum and is tame enough to be picked up and handled. Gray has other tarantulas, but most are too "frisky" to tolerate handling. Years ago, one of the tarantulas escaped from its cage. After several weeks, Gray received a

Books

from The American Museum
of Natural History

COSTUMES OF THE EAST, by Walter A. Fairservis, Jr., shows the great variety of exotic, romantic garments worn by the peoples of Asia, from the Middle East to China, from Lapland to Japan. Cultural and geographic aspects of the clothing are discussed, and beautiful color plates and black and white drawings show the rich detail of the costumes. Anthropologists, clothes designers, and devotees of Oriental art will appreciate the value of this book both as a reference and for sheer pleasure. Cloth $15.00, paper $5.95

ANCIENT MEXICO AND CENTRAL AMERICA, by Gordon F. Ekholm, analyzes the art and architecture of precolumbian Middle America. Superb color and black and white photographs by Lee Boltin picture items from the Museum's Hall of Mexico and Central America. Archeologists and sculptors will find this book beautiful as well as informative. Paper $5.00

BUTTERFLIES OF THE AMERICAN TROPICS, by William Phillips Comstock, is the definitive work on the genus *Anaea*. With 30 full-size color plates and hundreds of detailed drawings, this authoritative publication is a must for collectors of extraordinary books as well as for collectors of Lepidoptera. Cloth $25.00

CURASSOWS AND RELATED BIRDS, by Jean Delacour and Dean Amadon, explains and illustrates the habits and biology of curassows, guans, and chachalacas, a fascinating group of gamebirds from tropical America. This large volume has 30 magnificent color plates of paintings by Albert Earl Gilbert, George Miksch Sutton, and David Reid-Henry, as well as many drawings, photographs, and maps. Ornithologists and lovers of fine bird paintings will delight in this work based on several field trips and extensive research. Cloth $20.00

NATURALIST'S COLOR GUIDE, by Frank B. Smithe, is important to all naturalists, especially ornithologists, whether amateur or professional. Part I, a pocket-size binder with 86 swatches of named, measured colors, is essential for precise identification and description of birds and other animals. Part II, a paperbound supplement, discusses each color, how it was named and measured, and the work of various color specialists, such as Robert Ridgway. Part I $9.00, Part II $5.00, both parts together $12.00. Part III available soon.

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call from someone who had found the spider wandering around Central Park some four blocks north of the Museum. "I recognized it," Gray explains, "by the balding pattern of hair on its abdomen."

Gray's collection was augmented last summer by two praying mantises: one found in a ladies' restroom on the forty-fifth floor of the Empire State Building; the other discovered on a window ledge on the thirty-eighth floor of a Wall Street office building. Apparently, Gray explains, the hapless insects were caught in updrafts of air from the hot city streets.

A different collection of fauna inhabits the Herpetology Department. All the animals there are part of research projects, except for the poisonous marine toad, which in the words of one assistant is "our public relations toad." Charles J. Cole, an associate curator, keeps a colony of female whiptail lizards. The study of these lizards, which reproduce entirely without males, is providing valuable information about parthenogenesis (reproduction by the development of an unfertilized egg), adaptation, and ecology.

Next door, curator Charles W. Myers's office is crowded with South American poison-dart frogs. He is

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# 1981

## April

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# NATURAL HISTORY

[illegible] of the Fish, a Buddhist diety associated with mercy and ab[illegible] [illegible] from the Gardner D. Stout Hall of Asian Peoples, Ameri[illegible] [illegible] with support from the Henry Luce Foun[illegible]

# 1981

## January

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## February

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## March

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# NATURAL HISTORY

A Buddha in the Sukhothaian style, in bronze. It is in a display of Buddhas at the Gardner D. Stout Hall of Asian Peoples, American Museum of Natural History. Photography, with support from the Henry Luce Foundation, by Lee Boltin.

working on a collaborative study of the highly toxic, biomedically important alkaloids secreted by these brilliantly colored frogs.

For a number of years, the Mammalogy Department was the home of a family of ferrets. Two of these small, weasellike animals, a male and an albino female, were given to the tannery to be reduced to study skins and skeletons. Instead of turning them into skins and bones, the tannery technician adopted them as pets. Peppy and Peppina had several litters before they died, and the last of their offspring, Jeb, was a Museum favorite. He had the run of the place and even learned to ride the elevators. One day, however, he met with misfortune and fell down the elevator shaft. Telling of the accident, a technician in the department sadly shakes his head. "No more ferrets," he says.

Of all the animals that have inhabited the Museum, none was more beloved than Meshi, a chimpanzee. Henry C. Raven, a staff anatomist, found Meshi in the French Cameroons in 1929 and brought the orphaned animal back to New York. Raised in the Raven home as another child (one of the first times such an experiment had been tried), Meshi was a frequent visitor to the Museum. Her favorite pastime was riding a kiddie car back and forth along the Museum's fifth-floor corridors. She often lunched with the president of the Museum, Henry Fairfield Osborn. On these occasions, Meshi would ride her kiddie car to the elevator, descend to the second floor, and pedal into the staff dining room, where she would eat with a spoon while seated in a high chair.

When, like most pet chimpanzees, she became morose and violent in the later years of her life, Meshi was given to a zoo in Chicago. When she died, her body was shipped back to New York where Museum preparators mounted it. Today, visitors to the Museum can see her in the Hall of Primates, sitting on a log, with a contemplative, philosophical look in her glass eyes.

*Douglas J. Preston*

**Expedition to New Guinea**

In 1953, acclaimed Museum ornithologist Thomas Gilliard embarked on an expedition up New Guinea's Sepik River to visit regions previously unexplored by scientists. For the December Members' Program, Mary LeCroy, another Museum ornithologist, will show Gilliard's film of the expedition and talk about his work in New Guinea. LeCroy, who is an expert on New Guinea birds of paradise, will present the *Sepik River Expedition* on Wednesday, December 17, at 7:30 P.M. in the Auditorium. Members are admitted free; $3.50 for nonmembers.

**African Music and Dance**

*Dinizulu and His African Dancers, Drummers, and Singers* will present two narrated concerts in the Auditorium on Sunday, December 14, at 1:00 and 3:00 P.M. The program will include such dances as the *Egungun*, a secret-society dance of Nigeria, and the *Bamaya*, a Ghanaian dance of gaiety and dignity. Other highlights of the afternoon will be singing and solo performances on the thumb piano and drums. The concerts are free.

**Man and Nature**

Four films on the subject "Man and Nature" will be shown in the Auditorium on December 6 and 7, from 2:00 to 3:15 P.M. The films, which are free, include *Beluga Baby*, about a whale born in captivity; *Osprey*, about the return of this bird to the Scottish Highlands; and *Mysterious Castles of Clay*, about the African termite and its monumental nests.

**Theater of the Deaf**

Four deaf actors and one hearing actor will present a theater piece based on the life of the Japanese poet Issa. This free program, given at 2:30 P.M. in the Auditorium on December 27, 28, 29, and 30, is especially suited for children. *The National Theater of the Deaf* is presented in association with the Touchstone Center.

**Holy Land Before Christ**

Claireve Grandjouan, professor of classics at Hunter College, will give a slide lecture, *The Holy Land Before Christ*, in the Auditorium on Wednesday, December 3, at 7:00 P.M. She will discuss the most recent archeological finds in the Near East and how they shed light on the region's ancient civilizations. Tickets are $5. Call (212) 873-7507 for ticket availability.

**Courses for Stargazers**

The American Museum–Hayden Planetarium is offering a winter semester of courses in astronomy, aviation, navigation, and astronomy for young people. Course catalogs and preregistration forms may be obtained by writing to the Planetarium.

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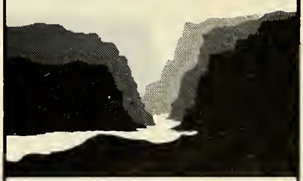
Joseph L. Sax
Mountains Without Handrails
Reflections on the National Parks



Sax proposes a novel scheme for the protection and management of America's national parks, giving perspective to the longstanding and bitter battles over use of our national parklands: hikers vs. cyclists; ski resort developers vs. wilderness advocates; "industrial tourism" vs. recreational "elitism."

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# Additional Reading

**South Bronx Miracle** (p. 26)

B. Myerhoff's *Number Our Days* (New York: E.P. Dutton, 1979) is an anthropologist's personal account of her studies of elderly Jews in a senior citizens' center in California. An excerpt from the book appeared in the March 1979 issue of *Natural History*, pp. 76–85. Myerhoff collaborated with A. Simic on an anthology entitled *Life's Career—Aging* (Beverly Hills: Sage Publications, 1978), an exploration of aging in several ethnic groups. A classic in the field of gerontology, *Middle Age and Aging*, edited by B.L. Neugarten (Chicago: University of Chicago Press, 1968), is a collection of articles written in a sociopsychological framework, including A.M. Rose's "The Subculture of Aging" and G.F. Stribe's "Are the Aged a Minority Group?" M. Clark's "The Anthropology of Aging: A New Area for Studies of Culture and Personality" (*The Gerontologist*, vol. 7, 1967, pp. 55–64) proposes that the study of the elderly as a subculture is a valid anthropological inquiry. In *Culture and Aging* (Springfield: Charles C. Thomas, Inc., 1967), M. Clark and B. Anderson consider which personality types deal successfully with growing old.

**Weeds** (p. 36)

W.C. Muenscher's illustrated text *Weeds* (New York: Macmillan, 1960) identifies these plants and provides information about their control. *Weeds of Lawn and Garden*, by J.M. Fogg, Jr. (Philadelphia: University of Pennsylvania Press, 1943), illustrated by L. Hagerty, is a standard handbook of weeds for eastern temperate America; L.J. Crockett's *Wildly Successful Plants* (New York: Macmillan, 1977), illustrated by J. Bradley, is a handbook of North American weeds with an extensive bibliography. Written and illustrated by A.O. Dowden, *Wild Green Things in the City* (New York: T.Y. Crowell Publishers, 1972) introduces the characteristics of common urban plants during various months of the year. A textbook of plant synecology, R. Daubenmire's *Plant Communities* (New York: Harper and Row, 1968) provides an excellent general treatment of succession. F.H. Bormann and G.E. Likens's *Pattern and Process in a Forested Ecosystem* (New York: Springer-Verlag, 1979) describes a research team's work on regeneration after disturbance in the Hubbard-Brook Forest in New Hampshire. *Plant Strategies and Vegetation Processes*, by J.P. Grime (New York: John Wiley and Sons, 1979), discusses the evolutionary characteristics and life history strategies of plants. In "The Population Biology of Dandelions" (*American Scientist*, November–December 1971, pp. 684–94), O.T. Solbrig explains how these common, successful weeds are adapted as a group to taking advantage of environmental disturbance. R.H. Whittaker's *Communities and Ecosystems* (New York: Macmillan, 1975) is a general, illustrated text that includes a large bibliography. For a review of the literature on weeds, see H.G. Baker's "The Evolution of Weeds" in *Annual Review of Ecology and Systematics* (vol. 5, 1974, pp. 1–24).

**Tropical Salamanders** (p. 46)

Much of the literature on tropical salamanders is technical. The Grzimek *Animal Life Encyclopedia* (volume 5), however, has a large, readable section on tropical salamanders. For a comprehensive, illustrated review of the subject, readers should consult D. Wake and J. Lynch's "The Distribution, Ecology, and Evolutionary History of Plethodontid Salamanders in Tropical America" (*Science Bulletin, Natural History Museum of Los Angeles County*, 25: 1–65, November 19, 1976). "Genetic Differentiation, Albumin Evolution, and Their Biogeographic Implications in Plethodontid Salamanders of California and Southern Europe" (*Evolution*, vol. 32, 1978, pp. 529–39), by D.B. Wake, L.R. Maxson, and G.Z. Wurst, presents data concerning genetic differentiation among the five species of *Hydromantes*. A two-article series by R.E. Lombard and D.B. Wake entitled "Tongue Evolution in the Lungless Salamander, Family Plethodontidae" explores in detail how the salamander tongue works. The first article, "Introduction, Theory, and a General Model of Dynamics" (*Journal of Morphology*, vol. 148, 1976, pp. 265–86), includes many diagrams and a photograph showing a retracted *Hydromantes* tongue; the second, "Function and Evolutionary Diversity" appeared in volume 153, 1977, pp. 39–80. Both articles include helpful bibliographies.

**Comets** (p. 54)

Illustrated with many photographs, P.L. Brown's *Comets, Meteorites and Men* (New York: Taplinger Publishing Co., 1974) is a thorough introduction to the physical nature of comets that explains many aspects of comets and meteorites, including their different components, what their motions reveal about different theories of the solar system, and the scientific controversies that exist about them. Another illustrated introduction to comets, P.

Moore's *Comets* (New York: Charles Scribner's Sons, 1976), discusses the basic structure of a comet and its relation to the solar system and gives accounts of some successful comet hunters and their finds. Among the comets discussed in this book are Biela's and Halley's comets and the disappointing Comet Kohoutek. R.S. Richardson's *Getting Acquainted with Comets* (New York: McGraw-Hill, 1967) is an illustrated, easy to understand text with instructions on comet watching for beginners. For a discussion of the origin and formation of comets and their tails, see R.A. Lyttleton's *The Comets and Their Origin* (Cambridge: Cambridge University Press, 1953). "When Halley's Comet Bemused the World," by J. Klein (*The New York Times Sunday Magazine*, May 8, 1960), is about the comet's 1910 appearance and T. Morris's "The Boy Who Redeemed His Father's Name" (*Reader's Digest*, January 1966) tells the story of comet finder Ikeya. "A Sad Tale of Two Comets" (*Astronomy*, February 1980) describes the NASA mission that will explore Halley's comet and Tempel 2. A good source of scientific literature on the subject is the large, two-volume work published by NASA entitled *The Study of Comets* (Washington, D.C.: Scientific and Technical Information Office, NASA, 1976), edited by B. Donn, M. Mumma, W. Jackson, et al. This collection of papers is from IAU Colloquium No. 25, held at the Goddard Space Flight Center, Greenbelt, Maryland. Among the papers that appear in this comprehensive work is M. Oppenheimer's "Gas Phase Chemistry in Comets" (vol. 1, pp. 753–63).

*Rita Campon*

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# Celestial Events

### by Thomas D. Nicholson

**The Moon** Evening skies are dark and moonless for the first week in December (and again in January) because the waning crescent will be in the morning sky. New moon occurs on December 7. The first evening view of the young crescent moon should be possible on about the 10th. First-quarter is on the 14th, full moon on the 21st, and last-quarter on the 29th. The new moon will appear again on January 6th and first-quarter will be on the 13th. Apogee moon (farthest from the earth) is on December 2 and 30 and perigee moon (nearest the earth) is on December 18 and January 14.

**Stars and Planets** Every planet but Mars is a morning star for most of December and all but Mars and Mercury continue in the morning sky through January. Planets, as you might expect, are thus poorly represented in the evening sky. The morning planets fortunately more than make up for the deficiency. Jupiter and Saturn rise near one another about midnight; Venus about an hour before dawn. Best dates are December 1 to 4 and 28 to 31 when the waning moon is passing the planets. The sun moves out of the constellation Ophiucus and into Sagittarius after mid-December. Mercury leaves Libra, passes through Scorpius and Ophiucus, and joins the sun in Sagittarius in late December, moving ahead of it into Capricornus in January. Venus follows the same path through Libra, Scorpius, and Ophiucus, but stays behind the sun, leaving Ophiucus and entering Sagittarius in early January. Mars is in Sagittarius for most of December, Jupiter and Saturn are in Virgo, Uranus is in Libra, Neptune is in Ophiucus, and Pluto is in Bootes.

December 1: From moonrise (about midnight this morning) until dawn, the moon is very close to Jupiter and Saturn (Jupiter is the brighter of the two). Venus, brighter still, rises below them and to their left before dawn.

December 4–5: The waning moon is near Venus on these two mornings. Jupiter and Saturn are well above them to their right.

December 8: Earliest sunset of the year (north of the Equator).

December 9: The setting moon may help you find Mars tonight, in the west below the moon about an hour past sunset.

December 13–14: Look for the Geminid meteors on either morning, a reliable and productive (50 per hour) shower.

December 21: The sun arrives at the winter solstice and winter begins in the Northern Hemisphere at 11:56 A.M., EST. This is the shortest day of the year north of the Equator.

December 22: The Ursid meteor shower is at maximum (about 15 per hour).

December 28–29: Jupiter and Saturn are much closer to each other than earlier in the month. The moon passes them again tonight.

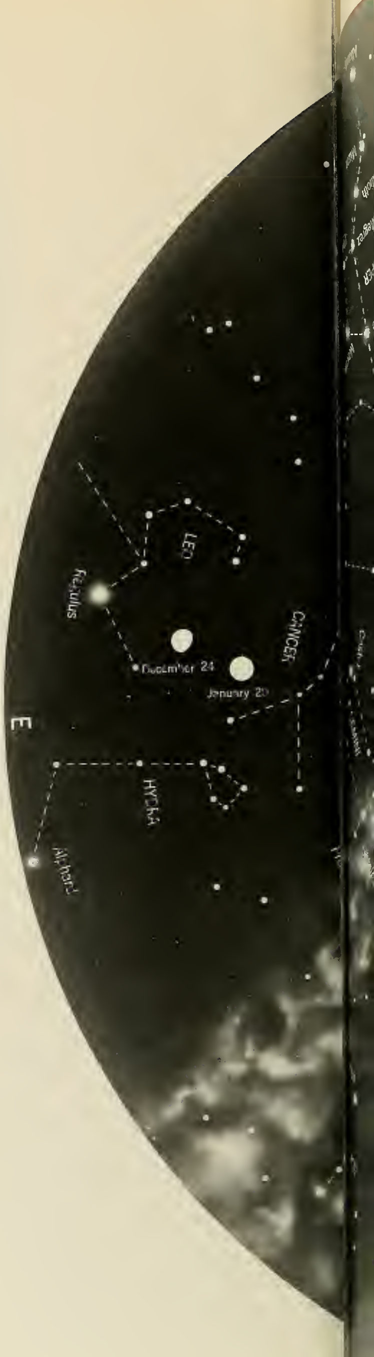
December 31: Mercury aligns with the sun in superior conjunction (beyond the sun), entering the evening sky.

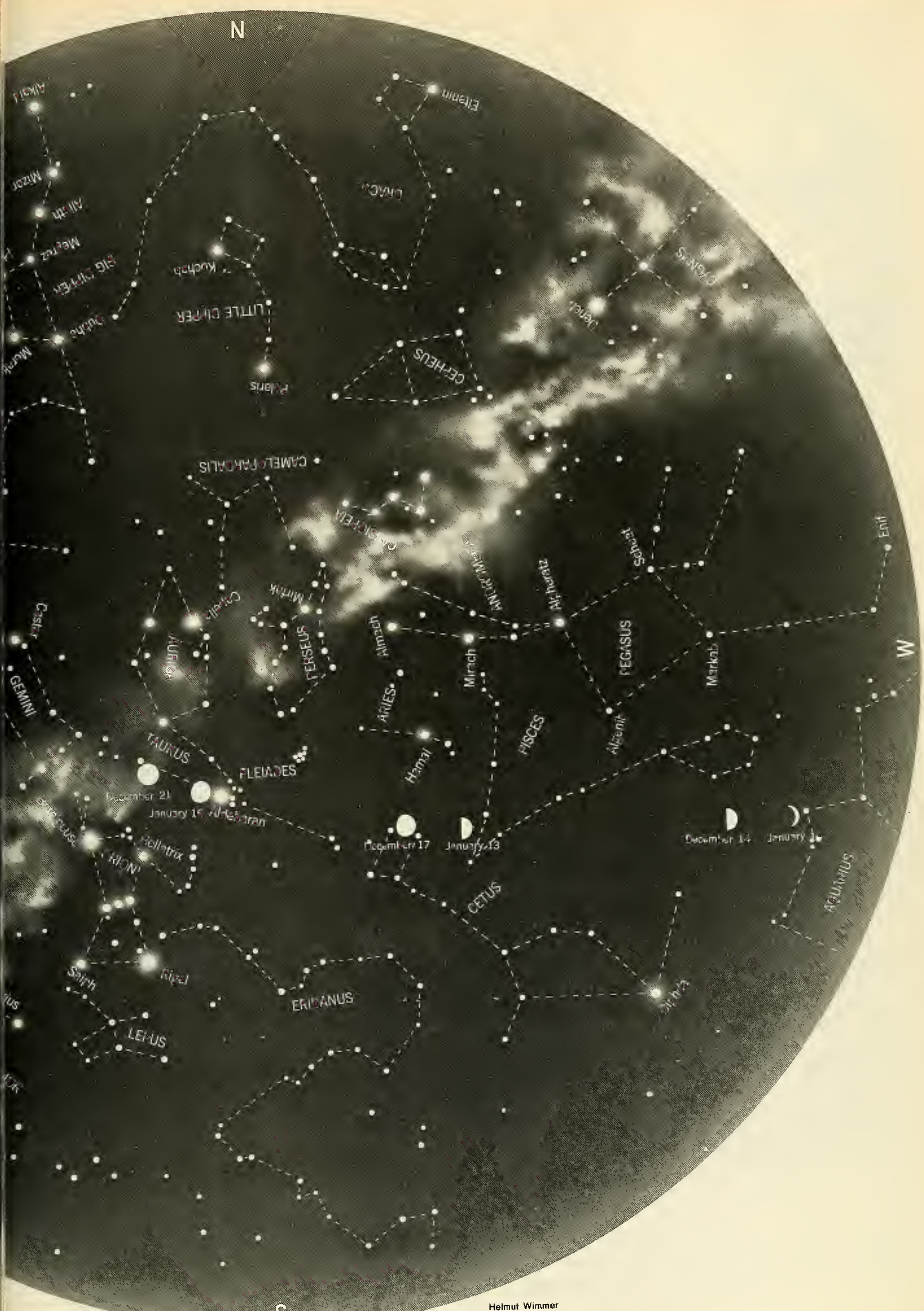
January 1: Earth is nearest the sun (perihelion), about 147,093,000 kilometers (91,400,000 miles) from it.

January 6: The latest sunrise of the year occurs north of the Equator.

January 14: Jupiter and Saturn are in conjunction.

**Evening Star Map:** To identify stars in the northern sky, hold the map in front of you with north at the bottom and match the stars on the lower half of the map with those in the sky. When you face the other directions, roll the map to bring the corresponding compass point (east, south, or west) to the bottom, and match the stars in the sky with those on the lower half of the map. The map represents the sky at about 11 to 12 P.M. on December 1; 10 to 11 P.M. on December 15; 9 to 10 P.M. on December 31; and 8 to 9 P.M. on January 15. It shows only planets and moon phases above the horizon at those times.

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# A Gathering of Birds

### by Robert Arbib

A Field Guide to the Birds, by Roger Tory Peterson (fourth edition). *Houghton Mifflin Company, softcover $9.95; hard-cover $15.00; limited signed edition $90.00; 384 pp., illus.*

The news has already reached the farthest corners of the continent, and armies of birders, kitchen window watchers, and librarians are already rushing to snap up the long-awaited, "completely revised and enlarged" edition of Peterson's original launching pad to fame and fortune, his eastern guide. It is thus uncertain in the mind of this reviewer whether to treat its arrival as a historic event or to review it as an addition to the ever-more-crowded shelf of field guides.

As an event, it signals the first revolutionary revision of the field guide that started it all in 1934, and which, after one minor and one major revision, has sold almost two million copies. But more than that—as has so often been said (every time the author wins another prestigious medal or honorary degree)—it is the book that did more to popularize natural history and father the conservation movement than any other, including even Rachel Carson's *Silent Spring.*

As advertised, this edition is almost completely new and represents a quantum leap forward from its most recent predecessor, and here some specifics are in order. Several immediate improvements should be noted at once: the color plates, at last, now face the text for the species shown—no more searching for text and corresponding illustration on widely separated pages. For the first time there are excellent range maps—390 of them—the work of Virginia Marie Peterson (principally) and her husband, Roger. Not postage-stamp maps either, but six to a page, legible maps with state and province boundaries shown. The color scheme is borrowed, perhaps, from the Robbins-Bruun-Zim-Singer field guide: pink for breeding range, blue for winter range, purple for overlap, with many marginal notes, such as (for rose-breasted grosbeak) "winters casually to n. U.S. at feeders," or (whip-poor-will) "recent decline in many areas."

Another cried-for improvement is the updating of the bird list itself, with literally scores of species added to the text and shown in color plates. I counted an additional 137 species or forms in this present edition; most

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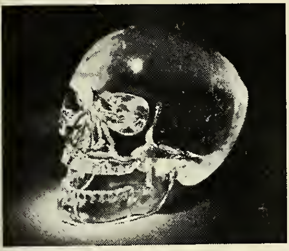

This photo is of the Maya Crystal Skull and is an example of the subjects that you can read about. Popular Archaeology is a magazine on world-wide archaeology that is written in an easy-to-read style and is well illustrated. You will receive articles on the pyramids of Egypt, American archaeology, Roman and Greek archaeology, human evolution, the scientific methods used in archaeology and notices on opportunities to do field work. We are now featuring a continuing column entitled "The Unexplained." Edited by professional archaeologists, you can read into "The Mystery and Excitement of the Search and Excavation" and discover factual material about the history of our civilization. Subscription is $9.75 for one year, $15.00 for two years and $20.00 for three years, all of which are guaranteed. Each new subscription will include free good-reading back issues.

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are the result of knowledge gained by amateurs in the explosive growth of birding in eastern North America. The list of ocean wanderers—vagrants from the West, from Europe, and from the tropics—is truly remarkable and there are new color plates for each. Included are the many escapees—parrots and waterfowl especially—that have been found, some thriving, in the wild. Newcomers to birding who couldn't understand why common birds like the cattle egret or house finch were nowhere in the third edition will find them here.

Of all the features of the book, the color plates will undoubtedly draw the most comment. This edition has 136 full pages in color, as against the previous edition's 42. To get an idea of the simply prodigious labor that went into them, my tabulation showed 803 individual birds full figure, standing or sitting; 528 flying; 210 heads or heads and necks; 37 miniature birds; 34 drawings; 25 silhouettes; 7 chicks, 6 tails; 2 wings; and 14 separate feet. A grand total of 1,666 separate and distinct portraits, absolutely unguaranteed, but I'm not going through that again! Virtually every pose is here: mostly side views, but also those of birds flying, from above and below. The only views that are missing are the ones I have most need of in a field guide—the north end going south. The paintings themselves seem vastly superior to those in earlier editions.

As for the accompanying text, page layouts have imposed maximum brevity. Especially brief are the paragraphs on range, but the maps replace the words splendidly. We must not forget that this is a *pocket* field guide; it cannot illustrate every possible plumage of every species. Its system depends on key field marks as cues in an elimination process, and in most cases it will narrow the choices to one. In a few instances the guide suggests alternates for later, at-home decisions, but inevitably you will encounter puzzles that neither this nor any field guide can solve. You may be surprised to find that this edition, with so much added, is no larger than its predecessor. This is a feat I don't understand.

Negatives? The soft-cover edition and the dust jacket of the hard-cover are a hateful billboard, with a line across the bottom that screams "COMPLETELY NEW!" Fifteen years from now, when my copy is

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dogeared and ragged, it will still shout "COMPLETELY NEW!" at me, even though it will lack the twenty-five new additions to the regional bird list that will probably have been added since 1980.

Of course, most of the attention will be focused inside the covers. Already we have heard from a few of the hypercritical "experts," ready with magnifying glass to pounce on any suspected error. Isn't this bill too thin, those legs too long, the breast here too bright, the wings there too short? I'll leave this nitpicking to others. I did find some colors that particularly bothered me. In the copies I have seen, some plates have trouble with their blues: the American coot has a strong blue cast, those enormous (why so big?) kingfishers are solid blue, but the blue grosbeak is decidedly purple, and the robin-bluebird plate seems washed out. The answer may be in the printing of sixteen pages of color plates on each sheet: balancing colors accurately so that all are correct is difficult and may be impossible. Suffice it to say there are no illustrations that might cause confusion between species—save perhaps the *Empidonax* flycatchers, which are better separated by voice and habitat anyway. The new Peterson guide was not designed to solve those really difficult identification problems: all the immature gulls, cryptic flycatchers, problem raptors, juvenile pelagics, and uncommon hybrids. We need special, detailed field guides for those.

There may be people who will closely examine the maps and find fault with minor details. And for some species all the state and provincial boundaries should probably not have been included. They pin the map maker down to specifics where knowledge is still vague. But these are fine maps and having them all together in one section will make future revisions simpler.

So, finally, the time has come to retire your third edition to the shelf for good. This new Peterson was worth waiting for, and it's all you'll need in your kit bag for some years to come. Don't walk—run to your nearest bookseller!

*Robert Arbib writes for the National Audubon Society and also edits their bimonthly magazine,* American Birds. *His book,* The Lord's Woods, *won the John Burroughs medal as the outstanding nature book of 1972.*

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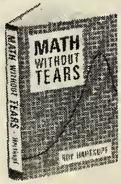

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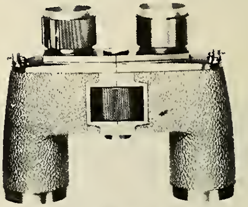

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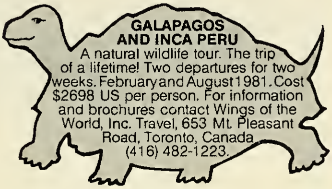

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Box numbers, telephone numbers, and hyphenated words count as two words; abbreviations and zip codes as one word each. All states are shown in two-letter code followed by zip, then telephone (with area code), if desired. Occasionally, slight editing is required for clarity. Thank you!

helped to stigmatize moonshining, making people aware that untaxed liquor is a drain on the commonweal and a peril to health. The antimoonshine literature explains that unscrupulous still operators contaminate their whiskey with toxic lead salts from car radiators used as cheapjack condensers instead of the conventional copper tubing.

To make matters worse, by the end of the sixties, courts were handing out moonshining convictions routinely and Treasury men found they could uncover many stills simply by monitoring suspiciously large sales of sugar. Indeed, sugar had become so basic to moonshining that the zoom in world sugar prices, which sent sweet tooths everywhere into a panic, had a lethal effect on marginal moonshiners. Old-timers who had kept working at their stills for lack of another vocation could no longer compete with cheap, legal whiskey. The high cost of sugar had priced them out of the market. These grizzled, folkloric bootleggers did not, by and large, return to moonshining, and few younger men moved in to replace them.

One retired moonshiner, Arthur ("Bad Eye") Williams remembers when he handled 500 cases of illegal whiskey in a week, fetching it from country stills and running it into Richmond, Virginia, where bootleggers like him used to congregate at an all-night restaurant in the Central Market and swap stories about fast chases with revenuers. His last arrest was in 1967, and after five years in federal prison, he finally went straight. Williams, half of his face disfigured from a booby trap that went off when he tried to steal a cache of moonshine as a boy, now finds the whiskey business too well policed, too risky. He hopes to make use of his special skills in a new, legit venture, a gasohol distillery.

Not every moonshiner in America has retired into nostalgia and law-abiding capitalism. Nearly everyone I have talked to in the southeastern mountain area claims to have a source for white lightning, usually a backwoods practitioner operating on a small scale. In most cases, however, these anachronistic mini-distilleries play as insignificant a part in the overall picture of American liquor production as, say, the homespun wool turned out by individual hobbyists around the country does in the total output of yarn in the United States. But in a handful of rural counties, "homemade" liquor is big business, highly organized and on an industrial scale.

Franklin County, Virginia, just east of the Blue Ridge, is by far the leading center of untaxed whiskey production in the land. Not long ago, the crusading Franklin *News-Post* established this fact in a carefully documented front-page story headlined: "FRANKLIN NO. 1 MOONSHINE COUNTY. No other area even close." The paper's editor-publisher, Kermit W. Salyer, who has been battling local moonshine interests for years, printed official statistics showing that during a two-year period in the late seventies, authorities seized 165 stills in the county with a mash capacity of 125,000 gallons. One still, destroyed by lawmen in 1972 at a site disguised as a cemetery, had a mammoth

Mike Wray

*In January 1980, Treasury agents blew up a still in Franklin County, Virginia.*

16,000-gallon capacity. Since it typically takes only five days to complete a "run" of a single batch of mash, that one site could have produced about 1.2 million gallons a year. With so much at stake, it is no wonder that the still owners do what they can to protect their investment.

Salyer contends that the whiskey interests in Franklin County have tried to put him out of business by setting up a rival newspaper, which siphons off advertising and circulation that might otherwise go to the *News-Post*. Salyer has, nevertheless, managed to keep his paper afloat and to spread the word about his county's dirty little secret. Because of his statistical exposé, published in late 1979, the U.S. Treasury Department and the Virginia Department of Alcoholic Beverage Control staged a raid on stills in Franklin County in January 1980. The national media were invited to bear witness. Salyer, in an editorial, dismissed the raid as a publicity stunt and called for more money to be spent on routine enforcement. He had a point.

Certainly, it did not require national television coverage and a feature in the *New York Times* to reveal what had been common knowledge. Local authorities do not try to conceal or deny the prevalence of moonshining. The casual visitor to the county administrator's office cannot fail to notice that the painting on the wall behind the receptionist's desk is titled *Franklin County Steamer*. It is an attractive picture of a classic still.

When I passed through Franklin County recently, no raids were in progress and I was unable to taste any of the locally celebrated, homemade fruit brandies. But I was invited to try samples of local white lightning by W. Q. Overton, the sheriff, who presides over Franklin County's grim stone jail. There, in a locked closet, which serves as the county's evidence vault, were secreted three nondescript bottles of homegrown hooch. Two of them contained whiskey that was powerfully alcoholic, clear as water, reasonably smooth tasting, almost as refined as commercial vodka. The third was more classic and had the sour taste that aficionados of moonshine prefer. This sourness is caused by a complex of chemicals that "puke" out of the still at the beginning of a run. At legal distilleries, these "sour heads" are drawn off and thrown away. Moonshiners, however, intent on maximizing production, often leave them in. The resultant taste is roughly similar to the characteristic flavor of tequila or those French and Italian spirits distilled from the dregs of wine making, which are known as *marc* and *grappa*, respectively. I mean this comparison only as a rough approximation. It would take a serious chemical analysis of these quite different drinks to establish which of the dozens of possible chemicals lay behind the special taste of each one, but there is definitely a family resemblance. And that has social as well as technical importance. The French, the Italians, and the Mexicans have continued to drink vigorous alcoholic beverages derived from a rural tradition of home distillation. Only in America have we shunned our ancestral liquor, abandoning it almost completely to criminal producers and a shrinking clientele at the fringes of mainstream American life.

*Raymond Sokolov is a free-lance writer whose special interest is the history and preparation of food.*

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**Mint Julep**

- 1 tablespoon sugar
- 1 tablespoon chopped mint leaves
- Shaved or crushed ice
- 2 ounces bourbon
- 1 small bunch fresh mint
- 2 drinking straws, cut short

1. Put sugar and crushed mint in a mixing bowl. Crush to a paste with the back of a wooden spoon.
2. Add a tablespoon of water to the mint-sugar paste and stir to produce a green syrup.
3. Fill a metal cup half full of shaved or crushed ice. (Special julep cups are sold for this purpose, but any silver cup will do. In fact, an ordinary tall glass will suffice, but will not, of course, frost in the same dramatic fashion as silver.)
4. Pour the green syrup and the bourbon over the ice. Slip in the sprig of mint so that it rises above the ice slightly. Insert the straws.
5. Place the cup on a tray without touching it, to avoid leaving fingermarks. Frost in the refrigerator. This will take thirty minutes to an hour.

Yield: 1 julep

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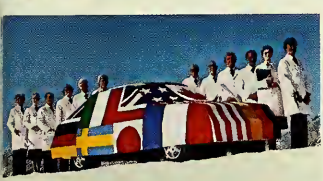

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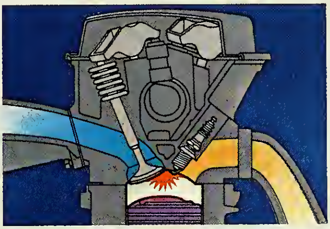

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**Canon® A-1**

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